AGRICULTURAL PROGRESS

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AGRICULTURAL EDUCATION ASSOCIATION

The object of the Association is the development of agricultural education and research by mutual assistance and advice It includes county agricultural organizers and instructors, and members of the teaching, research and advisory staffs of agricultural colleges, departments and research stations. The Association was established in 1894, and reconstituted in 1899 Its membership now is about 500

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"... Pater ipse colendi
Haud facilem esse viam voluit ..."—VIRGIL

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EDUCATION

REPORT ON THE ORGANIZATION OF SYSTEMATIC COURSES OF INSTRUCTION

BY PROFESSOR N. M. COMBER (*Chairman*) AND E. REA (*Secretary*) *of the Special Committee of the Association*

INTRODUCTION.

At a meeting of the Agricultural Education Association in July, 1918, there was a discussion, opened by Dr. Charles Crowther, on "The Reconstruction of Agricultural Education." The disorganization caused by the war had, as Dr. Crowther pointed out, brought agricultural educational activities into a state that admitted of reconstruction almost *de novo*, and it was urged that every advantage be taken of the opportunity thus presented. Following the discussion a Committee of thirty-eight members representing every sphere of agricultural education was set up "for the purpose of considering the Reconstruction of the Agricultural Education System and reporting to the Association." The report of the Committee was presented to, and adopted by, the Association in 1921.

It is quite impossible here to review the contents of the 1921 Report. They included a full treatment of every branch of agricultural education and research and the Report has proved of inestimable value in the difficult years that have followed the war.

When the 1921 Report was drawn up it was anticipated that the operation of the 1918 Education Act would set up compulsory continuation schools for young people of 14–16 years, and later on for people of 14–18 years. These anticipated classes in the rural districts were taken as the beginning of a scheme of Agricultural Education, and in the 1921 Report proposals for intermediate and advanced Education were related to them. Compulsory continuation schools did not, however, become established in the way provided for by the 1918 Act. Moreover, the subsequent formation of Senior Schools for people of 11–14 (following the Hadow Report) was not then foreseen.

During the ensuing years some County Organizers have attempted with some measure of success to organize classes for young people of immediate post-school age on a voluntary basis, and the need for

concentrating on this type of work has been emphasized from time to time. Also, the view has been gaining ground that in higher Agricultural Education the development of research has not been adequately balanced by the organized training and education of those who must chiefly be relied upon to apply knowledge to the industry.

At the General Meeting in Newcastle in 1934, the Association passed a unanimous resolution expressing the view that the organization of systematic courses of instruction, particularly for young people entering the farming industry, is a most urgent call on Agricultural Education Authorities. A Committee was then formed to see how such systematic courses of instruction can be developed and improved.

The following report of the Committee was adopted by the General Meeting of the Association at the Conference held at Bristol in July, 1935.

It is perhaps appropriate that that Committee should submit its report at a time when the farming industry is undergoing drastic reorganization and when a real need exists for defining the place and purpose of education in the conspectus of agricultural affairs.

COUNTY WORK.

Agricultural Education must become part of the normal education system in every rural area. It must be carried on, properly organized and systematized, just as regularly as teaching in the ordinary day school. County schemes should therefore begin with the elementary school.

While studies of life and living things should enter into the curriculum of all schools, much more is required in rural schools, and an organized system of agricultural education with its roots in such rural school work is an urgent necessity.

The Senior School.—There is already taking place a general movement to provide in rural areas senior schools, each of which will serve as a common centre of education for all children of 11 years of age and over, drawn from a number of surrounding junior schools.

These schools are, and will be, much better equipped and staffed than any parish school which hitherto has attempted to provide for all the educational needs of children up to 14 years of age.

In the Senior School rural science should be introduced at least in the last year, and preferably earlier, as is already done in some schools. The teaching of this science might with advantage be correlated with school gardening and the keeping of small live stock where facilities are afforded at the school.

The emphasis on rural science is of special importance in those senior schools which are away from a rural area and in an environment which is partly urban.

The important problem of the appropriate teachers for this rural science in the schools is dealt with later (see page 12).

School Leavers entering the Agricultural Industry.—A senior school is not likely to have much less than 300 pupils on its roll—some indeed may have many more—but 300 can be taken as a fair average for a senior school in a rural area. The number of "leavers" each year will be about 100, i.e. about one-third of the senior children.

The following is quoted from Board of Education Pamphlet, No. 99:

"The following table shows how the numbers entering these occupations vary according to type of district."

Types of District	Number of Schools	Number of Leavers	Proportion of boys in Agricultural pursuits On Farms	In Trades	Proportion of girls at domestic work.
Isolated villages ..	31	1,528	70%	11%	88%
Larger villages ..	22	1,980	62%	22%	80%
Villages with, or near factories	43	3,993	38%	25%	70%

"In a large number of cases domestic work includes dairying or the care of poultry. For example, of 614 girls from the schools in one district 35 per cent. are engaged in work of this kind, mainly at home."

"The following table refers to the leavers from 124 out of 314 departments in a southern county during the period July, 1922, July, 1932.

	Number of Schools.	Number of Leavers.	Proportion of boys working On Farms	In Trades.	Proportion of girls at domestic work.
Villages of less than 1,000 inhabitants ..	101	7,459	49%	15%	74%
Villages or small townships with, or near factories	23*	2,775	14%	15%	43%

"The above figures represent about one-third of the total number of children who left the elementary schools in the county during the

* Woollen mills and glove factories near their homes attract many of the leavers from these departments; the proportion in rural and domestic work is accordingly much lower than in any other group of schools included in the enquiry as is to be expected in a population which is mainly industrial, though located in the country.

ten years under consideration. About 2,300 boys and girls entered rural occupations and less than 10 per cent. of them had left the land for other occupations by the end of the period. In the case of a group of schools in another part of the country 714 boys began work on farms and only about 4 per cent. have left for other employment."

It would appear therefore that not less than half the number of leavers find their way into Agricultural service. If we assume that of the 50 leavers that pass into the industry each year half are boys and half girls, it seems possible to have continuation classes for both sexes of round about 25 in each.

The figures given above indicate that in rural areas with factories a much smaller percentage of leavers find employment in agriculture. On the other hand, schools in these areas will have usually more than 300 pupils on the roll, so that the actual numbers passing into agriculture should not be less than 25 each year.

**Continuation Classes for the ages* 14–16.—For the school leavers, whether from central schools or other elementary schools, who go into agriculture, classes for the two age years 14–16 should be provided. The teaching in these classes should, at any rate in part, be a preparation for later vocational classes, but at this stage in the proposed scheme of County Education there should be no segregation or discrimination in the teaching of a particular class according to the particular employment individual members are in.

It is hardly possible, and it is in any case inadvisable, to put forward here any detailed or rigid curriculum. In the formation of a particular class consideration must be given to what has been done in the school and how best to supply the educational requirements that most appropriately lie between that and vocational courses to follow in the years after the age of 16. In general, the work will include studies of plant and animal life accompanied by suitable laboratory and field work, some work involving calculation, and appropriate geographical and historical work. One aim should be to get into the minds of the scholars a satisfactory conception of the main *principles* involved in plant and animal life, to develop the capacity to think in an orderly way, and to develop a wide interest in the rural surroundings.

Manual work, not only woodwork, but work in field, garden and stockyard, where possibilities exist, should be included partly for its own intrinsic value and also because experience has shown that it has a great attraction and may serve to retain in a class young people who might not be held by the class room work itself. For

* In this Report "Continuation Classes" refers to classes for young people of the age range 14–16.

girls a domestic subject, including the use and preservation of home-grown products, should afford suitable practical work.

So far as is possible these classes should be held on one day a week and in the day time. A morning devoted to the science subjects and the afternoon to practical work has proved to be a satisfactory arrangement at some centres. An evening class is better than no class at all but is definitely second best to a day class. The scholars are much more efficient in the day time, and the day class should be regarded as the normal arrangement, the class being held in the evening only when a day class is really impossible.

While it would be unwarrantable to prescribe a rigid upper age limit for attendance upon these classes, it must be understood that classes arranged for young people of the 14–16 age range must not be open to attendance by people of maturer age. These classes, as will hereafter be considered, should stand in relation to the educational arrangements for older people in much the same way as a junior form stands in relation to a senior form in a properly conducted school.

The School Leaving Age.—The Committee has not considered itself called upon to express any view about the pros and cons of raising the school leaving age as it affects agricultural education. It does, however, express the view that if the school leaving age is raised to 15 the rural science of the last school year should be in substitution of the first of the two years Continuation Classes described above. That is to say, the scholar should be brought to the same stage in his agricultural education at the age of 16 no matter whether the school leaving age is 14 or 15.

The Recruiting of Continuation Classes.—It may be assumed that for the most part attendance at these classes will be voluntary. Moreover, public opinion in favour of such classes, while in some measure already awakened, has yet to be largely developed. Recruitment therefore calls for thought and energy. At the present day as much thought and work may be required in establishing a class as in conducting and maintaining it.

Conferences representing agricultural interests have proved useful in this matter. The personal persuasion of the schoolmaster or a member of the County Agricultural staff, while making heavy demands on time and patience, is perhaps the most effective procedure at the outset. It is better to commence with a small class of reliable and interested members, than to have higher numbers which will not be maintained.

The National Federation of Young Farmers' Clubs affords in many counties fruitful sources of recruits to day classes, and members

of the federated clubs who go into day classes are in an advantageous position in appreciating the relation of class teaching to farm practice.

The Teachers in Rural Schools and Continuation Classes.—If it is agreed that the scheme of Agricultural Education should have its roots in the rural schools and that the school education should be followed by continuation classes—if indeed these classes are to be *continuation* classes—there must be a close and considered relationship between the school work and the post school work. Three alternative arrangements suggest themselves, viz.:—

(*a*) Teachers of rural science in the school shall also take the continuation classes in agricultural subjects, the continuation classes being the responsibility of the Head of the school, and an extension of the work of the school with the necessary strengthening of staff.

(*b*) The teacher of the continuation classes shall be a member of the County Organizers' staff and shall be loaned to the school for teaching the rural science or at least the last school year of rural science. It is understood that this arrangement is in existence in one county.

(*c*) The school work shall be done by the school staff and the continuation class work by the County Organizers' staff, continuity to depend upon mutual arrangement between the two authorities. This is the arrangement in existence in several counties.

It does not follow, of course, that the teacher of the class room subjects in the continuation classes will be responsible for the practical work in workshop or field. Generally this work will be taken by another teacher engaged for the purpose.

The Committee is quite satisfied that the first of the above alternatives (*a*) is, in principle, the best. The allocation of the continuation classes to the schools would secure the foundation of the whole scheme of agricultural education in rural elementary education where, as indicated at the beginning of this report, it should be. While recognizing this alternative as the best in principle and expressing the hope that it will be possible to adopt it in some centres and to aim at it in all centres, it is also recognized that two practical considerations may make it impossible in most rural areas for the time being. First, there is a distaste amongst many rural children for anything that appears to be a mere continuation of school, and the conduct of the post-school classes by the school authorities will adversely affect recruitment. It is true, that this inertia will decrease with the development of Senior Schools but it will have to be

reckoned with, at least in some areas, for some time to come. Second, many farmers need to be satisfied before sending their children to classes beyond the compulsory attendance age, that the instruction is of practical significance, and is given by some one with practical farming experience. The County Organizer may therefore appeal where the school teacher does not.

The dispelling of these difficulties and the removal of any misunderstandings involved in them will be one issue of a successful development of agricultural education. In the meanwhile, however, they are very real and will be limiting factors in the arrangements made in many areas.

The staffing arrangements and the means of securing smooth working between school and post-school must vary from place to place for some time to come. Much will depend upon existing personnel. It is known for instance that in some schools there are teachers who have very successfully given their work a "rural bias" and arrangements are therefore possible in connection with such a school that may not be possible elsewhere.

One matter that calls for careful consideration is the qualification and ability of the teacher to teach young people of the 14–16 age range. Most members of the County Organizers' staffs have probably not had any special training in this type of teaching and the selection of suitable teachers is obviously of first importance.

Moreover, the salaries of the teachers should be such as to attract and retain good and highly qualified people.

Adult Classes for People over 16.—In dealing with educational arrangements for people of 16 upwards it should be noted that in addition to those who have passed from elementary schools through continuation classes, those who have been at the secondary school come under consideration. The two groups meet at this point.

There are two general alternatives for those over 16 who continue systematic agricultural education.

(*a*).—They may pass (having spent such time in practical farming as may be considered necessary in each case) either to a Farm Institute or to an Agricultural College or University, and all suitable people should be encouraged to attend an appropriate institution. The work of Farm Institutes, Colleges and Universities is dealt with in later sections of this report.

(*b*).—For those who cannot attend an institution, and in all counties in which there is no Farm Institute, the County Organizer should provide more advanced classes in agricultural subjects, and these classes should, wherever possible, he held in the day time.

The classes should be organized to cover a full curriculum in agriculture. For those who are not likely to attend a residential institute the course should extend over three years.

It must not be supposed that every one entering these classes is precluded from entering a College or University. The County Organizer should still encourage appropriate people in these classes to seek institutional training. Also it may be found from time to time that there are people in these classes who had no opportunity of matriculating in the usual way at school but who, on reaching the age of 23, can take the "mature" matriculation now offered by some universities and pursue a degree course.

Finance.—The Committee wishes to draw attention to the fact that since expenditure on County Agricultural Education is, in most counties, based on rateable value, counties with heavy industrial populations appear to have considerable advantages over more purely agricultural counties which are more sparsely populated. This matter appears to warrant early investigation.

The Farm Institute.

The Primary Function of a Farm Institute.—The primary function of a Farm Institute is to provide courses in agriculture, horticulture, etc., for students who intend to earn their livelihood on the land and who are not likely to take longer courses in colleges and universities.

The key-note of the agricultural teaching is management, and emphasis should be placed on the importance of accurate observation and the application of scientific method in all branches of work.

The practical work should include the teaching of skilled manual operations such as milking, shearing, thatching, soil cultivation, manure-sowing, pruning, grafting, budding, spraying, grading and packing, poultry killing and trussing, etc. The class room work should be designed to convey a working understanding of the main principles involved in husbandry and should as far as possible be related to the practical work carried out by the pupils.

The competence of the teachers of the practical work is a matter of great importance. A good craftsman is not always a good instructor.

It must not be forgotton that Farm Institute work like all educational work, should stimulate reflection, observation and constructive thought in connection with the affairs of life as a whole. Even at the sacrifice of some of the vocational instruction, the effort should be made to stimulate in the students a love of reading and a

real interest in such matters as the political, social and economic history of the countryside.

There must be co-operation between those who draw up the syllabuses for the continuation classes and those who design the Farm Institute courses. Indeed the continuation classes, the adult day classes and the Farm Institute courses should be considered together since the adult day classes constitute, for those who cannot give up a whole time period, the alternative to a Farm Institute course, while the continuation classes are a common precursor to both.

The Farm Institute and School Teachers.—The Farm Institute should seek to establish a close association with the teachers of rural schools in the country. Useful work can be done by giving advice and organized courses in connection with school gardens and by assisting teachers in the lay-out and use of their gardening and live stock activities. Moreover, vacation courses and so-called "revision" courses in general rural science should be arranged where possible.

Preparation for College and University.—It is a frequent stipulation that those entering upon degree and diploma courses must previously spend one year on an approved farm. The prevalent view has been that this period should be spent on a private farm and that Institute farms are unsuitable. It is considered, however, that a calender year at a Farm Institute can, in certain cases, be a very suitable compliance with the "year on a farm" regulation. The pupil may not be working under a farmer working with his own capital, but the study of management is a main feature of Farm Institute work and an unprejudiced source of instruction and guidance with nothing to withhold is at the pupil's disposal. For the townsman, a Farm Institute course seems a particularly useful preparation for College or University.

It is realised that this will not satisfy the existing requirements of certain examining bodies.

The Institute Staff.—One important staff question that arises where an Institute is included in a County Scheme of Agricultural Education is the relation of the County Organizer to the Institute. It has been argued that the County Organizer should be resident at the Institute and function as its Principal. It has also been contended that the County Organizer should be at the County's administrative headquarters and delegate the duties of a Farm Institute Principal to a resident colleague. Each of these arrangements has its advantages and no definite pronouncement which will be everywhere applicable can be made on the matter. The size of the

County will be one factor involved; the smaller the county the more there is in favour of the County Organizer being resident at the Institute. The personnel and existing distribution of the county staff is another factor, and it is clearly impossible to lay down that one particular arrangement is most advisable for all counties or even for one particular county for all time.

Similarly the distribution of duties between members of the staff of an Institute can only be considered in relation to the circumstances of each particular county. There are counties in which an allocation of some teaching duty, some duty in connection with the farm, garden or poultry plant, and some county work to each member proves quite satisfactory. In other counties each member of staff is mainly devoted to one or other of these categories of duty.

The essential thing is that each member of the staff shall appreciate his own responsibilities and also those of his colleagues and be prepared to orientate his work in the interests of the major purposes of the Institute.

The Institute Farm.—Three outstanding functions of an Institute farm are:—

(*a*) To provide means for demonstration of management and practical instruction in craftmanship for resident students.

(*b*) To provide a demonstration centre for farmers of the county.

(*c*) The collection of data, e.g. on rates of growth, cost accounts, etc.

The farming enterprises on the Institute Farm should be mainly determined by their industrial and financial importance in the county so that the teaching of students, the demonstrations to farmers and the accumulation of information may be largely related to the chief business concerns of the farmers of the county.

It may be contended, although it would not be agreed by all, that it is not necessary to have units of economic size for teaching purposes and that the agricultural and horticultural arts and crafts can be taught with less material than would be required for a commercial undertaking. But whatever view is held on this matter as far as the teaching of students is concerned, there seem to be over-ruling considerations if the farm is to function not only for the teaching of students but also for demonstrations to farmers and for the collection of data. A demonstration of management loses a good deal of its influence if the unit is less than what is taught to be a feasible minimum and if the method of management cannot be clearly correlated with a successful business reuslt; indeed, ***as a demonstration***, it may be

said to lose its essential value. Moreover, the amount of data that can usefully be accumulated becomes limited if the undertaking concerned is not on a commercial scale.

College and University Teaching.

The general purpose of a University Course in Agricultural Subjects.—In devising the curricula of agricultural courses it has generally been thought necessary to make those courses of the practical kind which are calculated to gain the sympathy and interest of the practical farmers. In a University this has, to some extent, been counteracted by university conceptions of education. The effect of these opposing tendencies, each of which has had its effect up to a point, has been to produce a conception that a university degree course in agriculture is essentially a training for the specialist rather than for the farmer. This view of the purpose of university degree courses is referred to several times in the 1921 memorandum.

It is considered that some effort should be made in the direction of dispelling this view of the purpose of university courses and of endeavouring to get more of the future farmers and landowners, who are able to profit by such courses, to take them. Particularly at the present time, when agriculture is being reorganized and the farmer and his affairs are so much before the industrial public, does the improvement of methods of educating the agriculturist call for attention.

This cannot be dealt with in any very rapid way but the attempt should be made to develop the future growth of agricultural education in that direction.

College and County Work.—The changes of outlook and conception referred to in the foregoing paragraph can only effectively be brought about by the closest co-operation between those responsible for the university and college courses and those responsible for every phase of county work. It is not suggested that close co-operation in the various provinces does not already exist, but it has been said that co-operation which finds expression in the Provincial Conference has been made use of, for the most part, in dealing with technical problems of agriculture rather than in dealing with the development of education as a training of individuals. If those attending young farmers' clubs, day classes and farm institute courses can be periodically surveyed with the object of considering in each individual case whether the pupil would profit by, and would be well advised to take, some more advanced course, it should, in due course, lead to a larger number of people taking more extended courses.

Similarly, University Departments and Colleges are considered

to owe some duty to the development of the county work. In so far as members of university staffs become interested in the county classes of all kinds and are able to give assistance and advice on methods of demonstration, sources of material, etc., a reciprocal interest between university and county work will be more firmly established for the benefit of all concerned. It is fully recognized that excellent work is done by the collaboration of college and county staffs in the Provincial Conferences but it is suggested that more might be done to develop the reciprocal *teaching* interests.

The Curricula of University Courses.—The curricula of university courses in agriculture have naturally been influenced by the technical requirements of the agricultural community. Such influences must always remain but it would seem desirable to make some changes now and again in the direction of a more personal training. It has been said that the agricultural curricula of our Universities and Colleges are not essentially different from what they were twenty-five years ago, and it is probably true that more changes might have been made during that period. Certainly the time has now come when it is desirable to arrange the curricula and time table of degree courses for agricultural students, to allow time for non-agricultural subjects to be taken. It is not suggested that there shall be introduced subjects which are divorced from the realities of life, but that some of the subjects shall be taken for their cultural rather than their technical value.

The curricula of many degree courses are divided into different subjects on the basis of the fundamental sciences. There is an allocation of time to agricultural botany with its syllabus, to agricultural chemistry with its syllabus, and so forth. This leads to considerable overlapping and some lack of co-ordination. It is neither possible nor desirable that overlapping should be entirely eliminated but it is considered that these courses could be well rationalized and devised on the bases of their actual subject matter rather than on the basis of the pure sciences. Instead of more or less independent considerations of what shall be taught under agriculture, agricultural botany, etc., there should be a general consideration of the subject matter of the whole course followed by allocations to the teaching staff. Thus it should be possible to avoid (taking two random examples) the "classification of soils" being fully dealt with both under agriculture and under chemistry and photo-synthesis being similarly dealt with under chemistry and under botany.

Such an arrangement will present some difficulties, but not insuperable ones, in connection with examination arrangements.

The University Department of Agriculture should give special attention to the training of people who are likely to go into Senior Schools or on to the County staffs and become teachers of the continuation classes. Students reading for degrees in agriculture who may possibly become candidates for such appointments might be encouraged to take some suitable course in education.

Scholarships tenable at Universities and Colleges.—There are considerable variations in the agricultural scholarship systems of different local authorities. In some counties there appears to be more scholarship money available than is needed for all the suitable applicants, and in other counties the reverse is the case. Some local authorities earmark a certain sum for agricultural scholarships, while others leave agricultural applicants to compete with all others for a certain number of scholarships. Also, some local authorities award their agricultural scholarships after consultation with the College or University, while in other cases the College is not consulted.

It is considered to be very desirable that education authorities should be urged to earmark specifically agricultural scholarships. Where this is not done the competition of agricultural with non-agricultural candidates is often very severe In the present position of agricultural education special encouragement and facilities should be given to students who can profitably take a college or university course, and it will be some time before agricultural candidates should be expected to compete with others for university scholarships.

It is also very desirable that authorities providing agricultural scholarships should be prepared when necessary to make an award to cover the whole cost. In some counties the maximum award does not cover the cost and suitable candidates from some of the humbler agricultural homes are precluded from taking courses which they could pursue with great advantage to themselves and the community.

Some county boroughs make awards of agricultural scholarships and it is much to be hoped that such provision will be made in other boroughs. Many boroughs have a number of farms within their boundaries and the young people brought up on them should have the same facilities as those on farms in the county area. Moreover, every possible encouragement should be given to the young people of the towns who have the desire and aptitude to do so, to enter an agricultural occupation.

It would be a great advantage if all awards could be made in consultation with the institution concerned.

The Place of Agriculture in University Education Generally.—A University Department of any subject has by its very nature to

consider its relation and duties to the whole realm of university studies. It has been said more than once that a University which has a department of Agriculture should endeavour to have some appropriate agricultural subjects included in the course of training of those who have no intention of being associated with the agricultural industry. It would be an invaluable thing to the country as a whole if even a small percentage of the university graduates of the last twenty-five years had acquired some knowledge and understanding of the developments and conditions of British agriculture. It is known that regulations to admit of this have recently been made in one or two Universities, although little advantage appears to have been taken of those regulations. Methods of personal persuasion will probably be the only ones that will get something started.

This consideration seems to be particularly important in the training of teachers, and the universities which have the facilities should be asked to do their utmost to have an appropriate agricultural course in the degree curricula of their registered students in training.

November, 1935.

THE INTRODUCTION OF AN AGRICULTURAL "COLOURING" INTO THE CURRICULUM OF SECONDARY SCHOOLS*

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The introduction of an Agricultural colouring into the curriculum of a Secondary School should be considered from the point of view of:

(1) The Future Citizen.
(2) The Future Worker on the Land.

The question arises in both cases as to whether such an introduction is, (*a*) desirable, (*b*) practicable.

As regards the future citizen, he should come to realize from what he learns at school the extent to which he is dependent, directly or indirectly, on the Soil, and on the efforts of those who labour upon it. He should also learn to appreciate something of the major problems and difficulties that confront the man who wrests his livelihood from the Land. Teachers who appreciate their responsibility can introduce into their lessons appropriate allusions.

* Abstract of paper read at London P.R.C., December, 1935.

Teachers of science, history, geography and civics should keep this point in mind in forming their syllabuses.

The least that a boy or girl should learn from their schooling is that Agriculture is a vast basic industry.

A "live" colouring of Agriculture and Biology (Natural History) is of importance, not only in the curriculum of Rural Schools, but of those situated in large industrial areas. In the case of the former, it will have many advantages, including the partial arrest of the flow of "black coats" to the towns. In the latter, it seems almost essential for the salvation of thousands who are growing up under the conditions of urban mechanization. It cannot be over-emphasized that this introduction is not only desirable, but, despite difficulties, quite practicable.

As regards the future land worker, the basic principle seems to be this:—The great currents of a changing world impinge upon the educational system of to-day, and every school that forms part of that system must re-act to influences from without. No school can isolate itself from its environment. It must recognise its relationship with that environment, with the influences it exerts and the facilities it affords as a medium of education. The future worker on the land should learn enough at school to realize that he must continue learning after he has left school, and to know enough to understand how best to set about learning more. The successful worker of to-day is usually the man who couples with his "close to the soil" wisdom, the mental attitude of the student. To citizen and soil-worker alike, one of the most valuable possessions is the open, enquiring, reflective and critical mind. The man who digs and delves below the surface of things comes nearest to true education. The closed mind that has been misled into thinking that all wisdom is to be found within the two covers of a text-book, is not susceptible to progress.

The drawing up of a curriculum suitable for the future land worker needs special consideration, but that such a course can be planned and that it presents no real difficulty is not disputed.

It is sometimes said that the introduction of an agricultural colouring on a practical basis, though desirable is impossible; further that the difficulties in a day-school are greater than those in a boarding school. It is submitted that these difficulties are more apparent than real. The cost difficulty has been unduly magnified and is somewhat of a "bogey." But even if additional expenditure is thereby incurred it should, in reason, be faced. In day-schools the time difficulty might be overcome by, (*a*) the extension of the day's work to 6 p.m. with a corresponding reduction in the amount of

home-work; (*b*) the allocation of a special half-day or block periods.

The attitude that the curriculum is already "overcrowded" is no argument; it is merely evidence of stubborn conservatism. Enthusiasm can stride over most obstacles.

It is not the function of a school to produce "half-hearted" workers whose chief desire is to escape from the hard work of farming and take up advisory work. Nor is it the function of a school to attempt to teach farming, but to provide the beginnings of an improved knowledge and a wider outlook.

It is not to be thought that some pupils who are interested in rural pursuits lack either intelligence or grasp of fundamental truths merely because they happen to be less articulate than others.

No school subject surpasses agriculture in its capacity to impart the quality of realism to the work done. Agriculture properly taught, must proceed by way of Mother Earth, and the problems which she presents are usually complex and not capable of simple solution.

Practical experience is of great value, but its value is increased when it is coupled with a reflective and critical attitude. The work done in schools should aim at producing this valuable combination; every lesson should be an adventure in discovery and not merely a piece of routine work calculated to produce a known result.

Practical lessons should consist of something more than mere instruction in the performance of technical operations. Everything that the pupil learns should leave him satisfied "so far," but anxious to learn more. For this reason big pieces of work, co-operative, creative and worth doing, should form an essential part of the year's work.

For craftwork and rural studies, *Instructors* are frequently employed, for other school subjects, teachers. Why? As for other school subjects craftwork and rural studies require the services of inspiring men and women. Inspiration must lie at the heart of the teaching for it is certain that no real advance will be made in the teaching of these subjects, whatever thought and trouble be given to the framing of syllabuses or schemes of work, unless a fountain of inspiration be the main urge.

The syllabus of work to be done should be built up on considered principles and adapted to the facilities afforded by the school and its neighbourhood. In all probability no two school syllabuses will be alike, but they should agree in two respects at least:—

(1) In possessing a practical basis.
(2) In making pupils think.

It must be remembered that the pupil is being educated, and that his general education, broadly conceived, must be continued.

Much mischief can be done by young and inexperienced teachers, who make use of a syllabus founded mainly on the basis of college notes, which syllabus often bears little relationship to the needs of pupils, or the facilities available.

The mind of the agriculturist needs to be alert and vigorous, critical and independent. All the training he receives should reflect this aim. His should be a mind that will not accept statements without question. The mind that unsuspectingly regards a so-called fact as a whole truth is ill suited to solve the problems or to face the buffets that nature will provide: (the tidy diagram of the "nitrogen cycle in nature" will have much to answer for one of these days).

The work done in school should not only establish certain fundamentals, it should act as a spur to the imagination, stimulate thought and provide a healthy incentive to consider problems.

Clogging the pupil's brain with an accumulation of useless facts tends to destroy initiative and effort. Danger lurks in the unintelligent use of the text-book and test-tube, for seldom is it that any simple test can be applied to the solution of such complicated problems as agriculture will present.

Demonstrations and experiments conducted outside the limits of the laboratory or garden need not necessarily be expensive, elaborate, or difficult to carry out. It should, however, be recognised by the responsible authorities, that reasonable expenditure on well-designed laboratory work or field-work is essential to the success of a course of rural studies.

A sound scientific basis is essential to a course of rural studies, but the teaching should be neither book-taught nor examination ridden. Applied mathematics, mechanics, woodwork, engineering and general science should be properly linked up. Theory and practice must be closely correlated.

School gardens, a kitchen garden (owned or borrowed), a school biological garden (if feasible), a school farm, a farm machinery shed, and out-door vivarium, poultry, pigs, cattle (if feasible); all such activities will tend to bring the quality of reality and an atmosphere of discovery to the work done.

THE ORGANIZED TEACHING OF AGRICULTURE TO WOMEN*

By Miss E. W. Jameson

East Anglian Institute of Agriculture, Chelmsford

The work of the countrywoman, typified by the wife or daughter of a farmer or smallholder, is extraordinarily diverse. If one were to enumerate the qualifications necessary to become the perfect farmer's wife, it might well frighten the average young woman from ever undertaking the position.

The countrywoman is, more often than not, engaged in some department of agricultural production. She may help with or manage the poultry, have the care of the garden, work in the dairy or tend young stock. She is a partner in the agricultural enterprise.

The country housewife, like her town counterpart, has, too, the general charge of the family, of the house and of the catering. Like her town sister she needs sufficient knowledge of food values to ensure the healthy feeding of the household. But, unlike the town housekeeper, whose problem is to *buy* with discrimination, she needs to *use*, to the very best advantage, the food produced on the holding. The success of the holding will largly depend on the skill with which commodities in season are consumed or preserved with due regard to maintenance of sales of these goods. This "long distance" catering (often carried on with poor equipment and in inconvenient surroundings) and the task of co-ordinating her "outside" and "inside" work are the distinctive problems of the country housekeeper.

The nature of the work which the country housewife is called upon to do necessitates her remaining at home on the farm, and entails a good deal of humdrum routine work. Opportunities for education which will make this work more interesting and inspiring are to be welcomed. How different a routine job becomes when one has learnt the "reason why." Education in its fullest sense will not merely provide information as to the best way of doing a thing, but provide matter for thought and interest, and in fact sometimes change the whole complexion of life.

The needs of the countrywoman are, therefore, of a rather special kind and any system of agricultural education must include, not only the teaching of subjects such as poultry-keeping, dairying, horticulture, but also the principles of dietetics and rural home management.

* Read at London P.R.C., December, 1935.

If any scheme of agricultural education is to be really efficient it must, of course, be general and become part of the normal educational system of all rural areas.

The special *Report on Agricultural Education* just issued by this Association stresses this point and suggests that county schemes must begin with the elementary school. Rural science could be introduced into the last year or last two years of the *Senior Schools*, correlated with school gardening, the keeping of small live stock, and, in the case of girls, some domestic science training.

Continuation classes for those of school-leaving age are recommended, where the pupils are encouraged to develop a wide interest in rural surroundings and taught the principles involved in plant and animal life. These classes might be the responsibility of the schools, or the County Organizer, or the two might co-operate in their organization and instruction.

Thus the young people are brought to the stage at which they may be given a more complete agricultural education by the Agricultural Staff of the respective counties. It is estimated in the Report just quoted that the senior schools are likely to have not less than 300 pupils, one-third of whom will be leaving each year. Of these one-half probably enter the agricultural industry, and half of these again will be girls. There are thus 25 girls leaving each year from a senior school whose work will involve the variety of jobs mentioned at the beginning of this paper.

In 1928 the Denman Committee, reporting on ' The Practical Education of Women for Rural Life," pointed out the necessity for providing more educational facilities for women in agricultural homes. This Committee was of the opinion that the opportunities open to women in the national scheme of agricultural education were more satisfactory on the higher than on the lower levels. Entry to University Courses is open to both sexes and provision is made for women at the agricultural colleges and at many Farm Institutes, but itinerant instruction could be still better adapted to women's needs.

In 1929 a circular letter was sent to the counties by the Ministry of Agriculture, wherein it was suggested, among progressive proposals, that instruction in Rural Domestic Economy should be developed. The need of at least one woman member on every county agricultural staff was also indicated and the usefulness of linking these two ideas by the appointment of instructresses in Rural Domestic Economy is obvious.

Before many counties had been able to follow up this idea the country was overtaken by the economic crisis of 1931 and any

additions to the staff of Farm Institutes, etc., became impossible. Now that some recovery has been made in the economic situation it is hoped that the suggestion made by the Ministry in 1929 will receive further consideration in the counties where no move has so far been made.

At the present time five counties in England and Wales are employing instructresses in Rural Home Management:—Essex, Carmarthenshire, Monmouthshire, Staffordshire, Yorkshire. In each case, with the exception of Staffordshire, the instructress is a whole-time member of the agricultural staff.

In Carmarthenshire the Instructress teaches women students at the Farm Institute during the summer term, and gives itinerant instruction (lecturing, e.g. to Women's Institutes) in the winter. In Essex the Instructress undertakes peripatetic instruction all the year round. When plans for the new Farm Institute materialize she may have an opportunity of teaching there. In Monmouthshire the Instructress teaches at the Farm Institute (where there is a demonstration kitchen, etc.) and also in the county. In Staffordshire, during the summer, the Instructress conducts a course at the Farm Institute, where there is a small demonstration kitchen; in winter she works in the county. In Yorkshire peripatetic teaching is undertaken by the Instructress all the year round.

Less ambitious efforts include the following:—Denbigh (a pioneer in this direction) added some domestic science to the women's summer course in dairying and poultry keeping at the Farm Institute. A similar arrangement obtains at Chadacre Agricultural Institute, West Suffolk. Derbyshire maintains the Day Classes for Farmers' Daughters, which have been distinguished for years past for their combination of agricultural and domestic instruction. In several other counties without farm institutes, e.g., Berkshire, Gloucestershire, Shropshire and Surrey, some rural domestic economy in different forms has been introduced into the county programme of itinerant instruction. In Shropshire, combined instruction in agriculture and domestic work is available at the Shropshire Technical School for Girls at Radbrook, Shrewsbury.

The qualifications of instructresses for this work must necessarily include some knowledge of domestic science as well as a knowledge of agriculture. Of those mentioned four hold agricultural diplomas (N.D.D. or N.D.H.) and have taken courses of varying length in domestic science.

The National Training College of Domestic Subjects (Buckingham Palace Road) and Swanley Horticultural College for Women have evolved a training course for those who intend teaching rural

domestic science. Students who have had a two-years' teaching course at the former college can take a one-year rural course at Swanley. The reverse process has also been tried—that of a student with an agricultural diploma taking a one year-course at the National Training College.

Some of the special work being done in Essex at the present time in the matter of women's agricultural education is as follows:—

(1) Day Classes are held during the winter months at three centres in the county, the centres being changed each year. Some difficulty is experienced in finding a time which is convenient to the students, who all lead exceedingly busy lives on the farm or smallholding at home. The result of this is, however, that the dozen or so who attend are extremely keen, having come at some inconvenience to themselves, and one can rely on their becoming "missionaries" who will introduce new ideas to those with whom they come in contact, in their particular district. A County Instructress in Rural Home Management is not only able to give the necessary help to such students in the utilization of the farm produce, but by linking her teaching to their work in the garden, dairy, or poultry yard, leads to an increased use of the services of the other specialized members of the County Staff.

(2) Lecture and demonstrations are given to existing women's organizations in the county, especially the Women's Institutes. In Essex there are 189 such Institutes, and one may expect an audience of anything from 20 to 120 according to the district. This provides an opportunity of making contact with very large numbers of countrywomen, and the Institutes themselves are keen to avail themselves of the facilities offered by the Agricultural Institute.

(3) At the Institute of Agriculture in Chelmsford there is a demonstration kitchen, where practical courses in Fruit and Vegetable Preservation are conducted during the summer time. At the moment the accommodation here is very limited and this section of the work could be extended if more room were available.

(4) A new Agricultural Institute building is, however, shortly to be erected in the county. Provision is being made in the plans for a larger and better equipped demonstration kitchen. It will then be possible to conduct courses in Rural Home Management for resident students at the Institute.

In July of this year, at the Sixth International Congress of Scientific Management held in London, a British paper was read

on "Scientific Home Management in Agricultural Areas." The information given regarding the conditions of work on smallholdings and in agricultural labourers' homes was the result of a special investigation made in the earlier part of the year. It was found that large numbers of countrywomen in England are working unduly long hours and with many serious handicaps, because of badly equipped houses and for lack of special vocational training.

It is desirable for the good of the countryside that the farmhouse kitchen should be at least as well designed as other modern farm buildings. It is certainly desirable that the country housewife should have an opportunity of learning those things which will enable her to carry out her many duties in the house and on the farm with pleasure and with profit.

In conclusion, one may reasonably hope that the effective training of countrywomen in the use of home-grown food would be of benefit not only to the agricultural home, but also to the industry as a whole, since it would help to popularize native produce, and reduce the consumption of tinned foods from other countries.

THE FINANCING OF AGRICULTURAL EDUCATION*

By J. Ll. Evans,

County Agricultural Organizer, Herefordshire

The question of the organization of systematic courses of instruction for those engaged in agriculture has been prominently before this Committee for the last two years. A sub-committee has gone into the matter with some thoroughness, and an admirable report was presented in the form of a paper which was read at the last summer meeting at Bristol. This report made suggestions with which most of those concerned with agricultural education will agree. The directions along which agricultural education should develop were clearly indicated, but since finance was considered to be outside the terms of reference of the sub-committee, no suggestions were made as to the methods which should be adopted to ensure that development should take place uniformly throughout the country. This problem must, neverthless, be faced, and it will be agreed that a scheme must be evolved which will give reasonably equal opportunities to those engaged in agriculture, wherever they may be living, to derive such benefit as may accrue from agricultural education.

Agricultural education in the counties is at present financed,

* Paper read to County Organizers' sub-committee, December, 1935.

partly by the local authorities, and partly by the Government acting through the Ministry of Agriculture, and Fisheries. The Ministry makes a grant of 60 per cent. of the total net expenditure incurred, leaving 40 per cent. of this expenditure to be borne by the local authorities. This arrangement might superficially appear to be just and equitable. Let us, however, examine the position in some detail.

I have gone to some trouble to prepare a table which gives the relevant facts. Column 2 in this table gives the product of a penny rate for General County purposes in each county. Column 3 gives the number of farmers and whole-time farm workers in the different counties on June 4th, 1933. The numbers of farm workers are given in the June Returns. I have assumed the number of farmers to be the same as the number of holdings, since this will entail not more than a slight variation. The figures in column 3 have been obtained by adding the two totals together. In column 4 is given the total population in the administrative counties as estimated in the middle of 1933. Column 5 gives the number of farmers and whole-time workers as a percentage of the total population. Column 6 gives the total net expenditure on agricultural education in each county in the financial year 1933–34, these being the latest completed figures which are available. Column 7 gives the proportion of this expenditure derived from local rates, and column 8 gives this local expenditure in terms of a penny rate. Column 9 gives the proportion of the expenditure derived from Ministry grants, and column 10 gives this Ministry grant per head engaged in agriculture. Column 11 gives the total expenditure on agricultural education per head engaged in the industry. In the table the order in which the counties have been placed is determined by the figures in the last column.

For the whole of the country, the total amount spent on agricultural education in 1933–34 was £323,362 and the total number of farmers and whole-time farm workers was 984,144 There was therefore an expenditure of 6s. 7d. per head engaged in agriculture, the average grant paid by the Ministry being 3s. 11½d. per head. The number of local authorities spending more than the average was 31. Between them, these authorities were responsible for 496,440 persons engaged in agriculture, and received £131,721 in Ministry grants.

The number of local authorities spending less than the average figure was 27. Between them these authorities were responsible for 487,704 persons engaged in agriculture, but only received £62,295 in Ministry grants. The first group received more than twice as much grant as the second, although concerned with a similar number of persons engaged in agriculture.

It is interesting also to note that the total population in the administrative counties in the first group (i.e. the "high-expenditure" group) amounted in 1933 to 15¾ millions, those engaged in agriculture representing only 3·16 per cent. of this total. In the second group (i.e. the "low-expenditure" group), the total population represented is just under 7 millions, those engaged in agriculture being 7·05 per cent. of the total. The counties which spend most money on agricultural education are substantially those in which the persons engaged directly in agriculture form a very small proportion of the total population. The following table illustrates the point:—

	Proportion of Farmers and Workers as a Percentage of Total Population.							
	Up to 2%.	2% to 4%.	4% to 6%.	6% to 8%.	8% to 10%.	10% to 15%.	Above 15%.	Total.
Counties spending above the average ..	4	10	8	3	2	3	1	31
Counties spending below the average ..	0	2	5	3	4	10	3	27

It is obvious that agricultural education has been, in fact, developed to the greatest extent in those counties which can draw for their own proportion of the expenditure on large bodies of non-rural residents within their areas. The factor which operates is ability to pay rather than the actual need as expressed by the numbers engaged in agriculture.

The same point is just as well illustrated by a reference to the rateable values in terms of the product of a 1d. rate of the various counties. The following table gives the position:—

	Expenditure on Agricultural Education in Terms of a 1d. Rate.					
	Up to ¼d. rate.	¼d to ½d. rate.	½d. to ¾d. rate.	¾d. to 1d. rate.	Above 1d rate.	Total.
Counties spending above the average	8	13	3	2	5	31
Counties spending below the average	6	13	5	1	2	27

The table discloses the fact that, in both groups, the local effort as measured by expenditure in terms of a penny rate is without significant difference. If we take an average, we find that the "high-expenditure" group spends just over a halfpenny rate, while the "low-expenditure" group spends a fraction under a halfpenny rate. The very small difference is accounted for by the

rather more cautious spending policy which naturally exists in counties with small rateable values.

The position as regards Farm Institutes is also a matter which should be touched upon. There are 18 counties possessing Institutes. There are rather more than double this number which do not yet enjoy this advantage. It must not be too lightly thought that the counties possessing Institutes are in this happy position only because they are progressive. In the main they are counties with high rateable values, easily able to carry that part of the expenditure which falls on rates. Of these 18 counties, 5 even in 1933–34 spent less than a farthing rate and 11 spent less than a halfpenny rate on agricultural education. Only 7 spent more than a halfpenny rate, and of these 4 spent only a fraction over the halfpenny rate. We are again face to face with the situation that it is the wealthy counties that are in a position to progress. Agriculturally, however, the other counties are just as important from a national point of view, but so long as the system of grant-giving decrees that national money shall go where there is already considerable local wealth, it is not easy to see how the majority of these can contemplate the establishment of Institutes. It is certain that, in order to do so, they would have to take upon themselves a local burden far in excess of that falling on most of those counties already in possession of Institutes.

The figures given must inevitably drive us to certain very definite conclusions. These are:—

(1) The expenditure on agricultural education in the counties of England and Wales varies within very wide limits. No kind of uniformity exists, and, as a consequence, we are far from achieving the ideal that those engaged in agriculture should enjoy similar facilities wherever they may be living.

(2) The most comprehensive schemes of agricultural education are being operated in counties which, in the main, have the highest rateable values and the largest populations. Proximity to large bodies of non-rural residents is an essential factor in the development which it has been possible to bring about.

Counties with low rateable values and comparatively small populations have not as yet succeeded in setting up comprehensive schemes of agricultural education. Most of these counties cannot, however, be charged with indifference to agricultural education if we measure their efforts by the money which they themselves find in terms of a penny rate.

(3) The grants received from the Ministry depend on the amounts which counties are prepared to find from their own resources. It is the wealthy counties which are able to spend the most money on agricultural education and it is therefore these counties which benefit to the greatest extent from Government assistance. "To him that hath shall be given."

There is no attempt to correlate Government aid with the actual need of each individual county. The present system of grant allocation is completely devoid of a logical basis and must be held mainly responsible for the wholly chaotic state of agricultural education as we see it in the counties of England and Wales at the present time.

If we condemn the present system of grant allocation, what can we suggest to take its place? We all agree that the purpose of agricultural education is to help to create a well-informed rural community, and our main pre-occupation must be with those directly engaged on the land. The number of these in any county can surely be accepted as the measure of the need of that county and the work which requires to be done in it. This number can be ascertained very easily from the June Returns, and it would seem reasonable to suggest that Ministry grants should be made on a capitation basis. It is possible that small adjustments should be made for such minor activities as do not come strictly under the heading of agriculture, such as allotments, bee-keeping, etc. Apart from these, there would appear to be no other factor which should be considered in arriving at a reasonable basis of grant allocation.

We are all equally concerned in the disposal of national money, and we cannot look with indifference upon its inequitable distribution. National money provided for agricultural education is, however, being most unevenly distributed, and no attempt has been made to correlate grant allocation with the needs of each county. I suggest that the time has come for the system of grants to be drastically revised in a manner which will permit every county to draw its due quota of national money on the basis of its actual needs and with due regard to the purpose for which the money is voted by Parliament. No valid reason can be put forward to justify the disparity in the treatment meted out at present to different farming communities. The system as it now exists clearly stands condemned, and the unfavourable position in which some counties are placed should not as a matter of common justice be allowed to exist much longer.

TABLE I.

County. 1.	Product of 1d. rate. 2.	No. engaged in agriculture, 4/6/1933. 3.	Total population, mid-1933 (estimated). 4.	No. engaged in agriculture as per cent. of total. 5.	Net expenditure on agric. education 1933-34. 6	Proportion of expenditure raised locally (40 per cent.) Total. 7.	In terms of a 1d. rate. 8.	Grants received from Ministry (60 per cent.) Total. 9.	Per head engaged in agriculture. 10.	Total expenditure on agric. education per head engaged in agriculture. 11.
	£				£	£	d.	£	s. d.	s. d.
1 Glamorgan ..	10,050	9,208	758,160	1·21	9,531	3,813	·38	5,718	12 5	20 8
2 Monmouth ..	4,216	7,918	341,490	2·32	6,623	2,649	·63	3,974	10 0	16 9
3 Hertford	12,321	13,151	421,200	3·12	8,859	3,544	·29	5,315	8 1	13 6
4 Flint	1,965	5,965	115,027	5·11	3,763	1,505	·77	2,258	7 7	12 7
5 Sussex E. ..	10,045	15,259	284,100	5·37	9,299	3,719	·37	5,580	7 4	12 2
6 Middlesex ..	62,336	6,908	1,756,820	·39	4,161	1,664	·03	2,497	7 3	12 0
7 Denbigh	2,737	10,712	156,500	6·85	6,382	2,553	·93	3,829	7 2	11 11
8 Durham	11,833	13,881	917,680	1·51	7,524	3,009	·26	4,515	6 6	10 10
9 Rutland	311	1,861	17,930	10·38	987	395	1·27	592	6 4	10 7
10 Notts	7,417	14,348	444,970	3·22	7,324	2,930	·40	4,394	6 1	10 2
11 Surrey	39,516	12,203	1,015,540	1·20	6,146	2,458	·06	3,688	6 1	10 1
12 Stafford	10,029	22,082	713,540	3·09	10,903	4,361	·43	6,542	5 11	9 10
13 Isle of Wight ..	2,316	2,788	86,040	3·24	1,378	551	·24	827	5 11	9 10
14 Essex	30,734	32,393	1,277,080	2·54	15,113	6,045	·20	9,068	5 7	9 4
15 Hampshire ..	11,814	22,333	482,500	4·63	10,169	4,068	·35	6,101	5 5	9 1
16 Berkshire ..	5,674	11,152	218,850	5·09	4,348	1,739	·31	2,609	4 8	7 9
17 Carmarthen ..	1,935	14,298	177,950	8·00	5,604	2,241	1·16	3,363	4 8	7 9
18 Derby	10,739	18,433	622,300	2·96	7,113	2,845	·26	4,268	4 8	7 9
19 Kent	35,949	39,414	1,250,000	3·15	15,373	6,149	·17	9,224	4 8	7 9
20 Sussex, W. ..	7,362	11,648	231,100	5·04	4,494	1,798	·24	2,696	4 8	7 8
21 Northants ..	3,633	12,122	214,300	5·66	4,626	1,851	·51	2,775	4 7	7 6
22 Caernarvon ..	2,223	8,985	119,500	7·53	3,398	1,359	·61	2,039	4 6	7 4
23 Bucks	6,917	11,981	279,940	4·28	4,441	1,776	·26	2,665	4 5	7 4
24 Somerset	8,907	29,062	403,330	7·25	10,679	4,271	·48	6,408	4 5	7 4
25 Devon	11,087	37,466	455,400	8·23	13,183	5,273	·48	7,910	4 3	7 1
26 Lancashire ..	36,968	41,869	1,802,730	2·32	14,722	5,889	·15	8,833	4 3	7 1
27 Anglesey ..	575	6,869	48,240	14·24	2,378	951	1·65	1,427	4 2	6 11
28 Cheshire	15,162	26,553	681,750	3·89	9,202	3,681	·24	5,521	4 2	6 11
29 Leicester ..	5,266	13,183	309,100	4·27	4,363	1,745	·33	2,618	4 0	6 8

TABLE I.—(*continued*).

County. 1.	Product of 1d. rate. 2.	No. engaged in agriculture, 4/6/1933. 3.	Total population, mid-1933 (estimated). 4.	No. engaged in agriculture as per cent. of total. 5.	Net expenditure on agric. education 1933-34. 6.	Proportion of expenditure raised locally (40 per cent.) Total. 7.	Proportion of expenditure raised locally (40 per cent.) In terms of a 1d. rate. 8.	Grants received from Ministry (60 per cent.) Total. 9.	Grants received from Ministry (60 per cent.) Per head engaged in agriculture. 10.	Total expenditure on agric. education per head engaged in agriculture. 11.
	£				£	£	d.	£	s. d.	s. d.
30 Lincoln (Holland)	1,207	17,402	93,590	18·60	5,799	2,319	1·92	3,480	4 0	6 8
31 Merioneth ..	562	4,992	41,760	10·95	1,657	663	1·18	994	4 0	6 8
32 Northumberland..	7,513	14,396	410,200	3·51	4,712	1,885	·25	2,827	3 11	6 7
33 Cambridge ..	3,289	11,103	143,780	7·72	3,518	1,407	·43	2,111	3 10	6 4
34 Warwick ..	7,900	14,948	362,200	4·13	4,825	1,930	·24	2,895	3 10	6 4
35 Westmorland ..	1,434	6,707	64,360	10·42	1,987	795	·55	1,192	3 7	5 11
36 Salop	4,200	24,728	243,900	10·14	6,957	2,783	·66	4,174	3 5	5 7
37 Dorset	6,032	13,715	241,900	5·67	3,633	1,453	·24	2,180	3 2	5 3
38 Yorkshire.. ..	35,958	88,960	2,042,571	4·26	22,841	9,136	·25	13,705	3 1	5 2
39 Cumberland ..	2,984	16,861	204,010	8·27	4,127	1,651	·55	2,476	2 11	4 11
40 Wiltshire	5,798	19,432	305,800	6·36	4,717	1,887	·33	2,830	2 11	4 10
41 Cornwall	4,937	25,211	312,076	8·08	5,971	2,388	·48	3,583	2 10	4 9
42 Cardigan	628	10,355	54,080	19·15	2,392	957	1·52	1,435	2 9	4 7
43 Brecon and Radnor	1,563	9,109	78,625	11·58	2,021	808	·52	1,213	2 8	4 5
44 Gloucester ..	5,910	20,810	337,700	6·16	4,573	1,829	·31	2,744	2 8	4 5
45 Montgomery ..	632	9,743	47,380	20·57	2,069	827	1·31	1,242	2 7	4 3
46 Oxford	2,297	10,797	130,950	8·25	2,249	900	·39	1,349	2 6	4 2
47 Pembroke ..	960	11,375	86,040	13·22	2,307	923	·96	1,384	2 5	4 1
48 Worcester ..	5,441	17,732	315,600	5·62	3,483	1,393	·26	2,090	2 4	3 11
49 Hereford	2,070	14,304	111,320	12·85	2,273	909	·44	1,364	1 11	3 2
50 Lincoln (Lindsey)	3,987	27,686	265,700	10·42	4,480	1,792	·45	2,688	1 11	3 2
51 Suffolk, W. ..	1,503	11,825	104,900	11·27	1,775	710	·47	1,065	1 10	3 0
52 Bedford	5,006	10,869	225,730	4·82	1,585	634	·13	951	1 9	2 11
53 Norfolk	4,291	44,915	321,900	13·95	6,132	2,453	·57	3,679	1 8	2 9
54 Suffolk, E. ..	3,602	19,542	209,320	9·34	2,448	979	·27	1,469	1 6	2 6
55 Lincoln (Kesteven)	1,666	12,156	109,880	11·06	1,387	555	·33	832	1 4	2 3
56 Huntingdon ..	779	7,005	56,250	12·45	571	228	·29	343	1 0	1 8
57 Isle of Ely ..	1,010	13,906	78,950	17·61	763	305	·30	458	8	1 1
58 Soke of Peterborough	1,177	1,514	52,370	2·89	24	10	·01	14	2	4

TABLE II.

SHOWING HOW EXPENDITURE ON AGRICULTURAL EDUCATION IS AFFECTED BY THE NUMBER OF FARMERS AND WORKERS AS A PERCENTAGE OF THE TOTAL POPULATION.

	Proportion of Farmers and Workers as a Percentage of Total Population.							
	Up to 2%.	2% to 4%.	4% to 6%.	6% to 8%.	8% to 10%.	10% to 15%.	Above 15%.	Total.
Counties spending above the average	4	10	8	3	2	3	1	31
Counties spending below the average	0	2	5	3	4	10	3	27

TABLE III.

SHOWING THE LOCAL EXPENDITURE ON AGRICULTURAL EDUCATION IN TERMS OF A 1d. RATE.

	Up to ¼d. rate.	¼d. to ½d. rate.	½d. to ¾d. rate.	¾d. to 1d. rate.	Above 1d. rate.	Total.
Counties spending above the average	8	13	3	2	5	31
Counties spending below the average	6	13	5	1	2	27

TABLE IV.

ILLUSTRATIONS OF ANOMALIES WHICH EXIST.

County.	No engaged in agriculture. (A measure of the need.)	As % of total population.	Local expenditure in terms of a 1d. rate. (A measure of the effort made locally.)	Ministry Grant.	Ministry grant per head engaged in agriculture.
		%.	d.	£.	s. d.
Hertford	13,151	3·12	·29	5,315	8 1
Sussex, E.	15,259	5·37	·37	5,580	7 4
Durham	13,881	1·51	·26	4,515	6 6
Notts	14,348	3·22	·40	4,394	6 1
Leicester	13,183	4·27	·33	2,618	4 0
Northumberland ..	14,396	3·51	·25	2,827	3 11
Warwick	14,948	4·13	·24	2,895	3 10
Dorset	13,715	5·67	·24	2,180	3 2
Hereford	14,304	12·85	·44	1,364	1 11
Isle of Ely	13,906	17·61	·30	458	8
Glamorgan ..	9,208	1·21	·38	5,718	12 5
Denbigh	10,712	6·85	·93	3,829	7 2
Cardigan	10,355	19·15	1·52	1,435	2 9
Montgomery ..	9,743	20·57	1·31	1,242	2 7

AGRICULTURE, ECONOMIC AND GENERAL

THE AGRICULTURE OF SOMERSET*

By W. D. Hay
County Agricultural Organizer

The 1,052,800 acres which make up the county of Somerset are of a most varied and interesting nature. Variety is the only term which can be used to describe all its natural and general features. Scenery, geological formations, contour, and farming practice are of almost every type and description. Thus to, generalize in any one feature is an impossibility.

The geological formations vary from the hard deep red Devonian rocks in the west to the greyish-white limestone in the Mendips, from the exceedingly fertile alluvial flats in the northern part of the county to the patches of Oxford clay in the south-east. Apart from these widely varying soils, new red sandstone, red marl, upper and lower lias, carboniferous coal measures, Green-sand and even a few patches of chalk—all must be included to complete the stony structure of the county.

The general contour of the county is just as varied as its geological formations, varying from the uplands of Exmoor and the Brendon Hills rising to some 1,400 feet to the "flats" around Bridgwater, some of which are below sea-level.

From the traveller's point of view, very few if any counties can boast of such wonderful and varied scenery. Beautifully wooded coombs and valleys contrasted with the richly coloured moors of heath and heather in the west, give way to the dark green rich pastures of the valleys in the centre of the county, backed up by the rugged scenery of the Mendips. The northern and eastern sections consist of a landscape, which though still beautiful, is rather less interesting.

The scenery of the county should not be left without some mention of the old stone-built houses and churches in which it abounds. Many of these beautiful buildings are of great historic interest, and are a source of never-ending attraction and interest to visitors.

*** Paper read at P.R.C., July, 1935.**

Climate and Area.

Somerset is fortunate in having an extraordinarily fine climate, except that, like other parts of the country, it sometimes has too much rain, and the average rainfall is between 30 and 40 inches; it rises to 50 inches at Wheddon Cross, and in the south-west the average is 60 inches at 1,000 feet. These figures convey very little as the important factor is the time of the year in which the rain falls, and strange to say, Somerset often suffers from drought at critical periods of crop growth.

The county is over a million acres in extent with approximately 133,000 acres arable. The population which has remained more or less constant during the last 100 years is between four and five hundred thousand; of these some 35,000 are employed in agriculture.

Somerset is a county of small farms when compared with other counties. The more important branches of its agriculture are dairying, pigs and poultry, stock raising and grazing sheep, wheat, barley, vegetable crops and cider making.

Types of Farming.

Bridgwater and Highbridge Flats.—In the centre of the county, composed of rich alluvial deposits, clay, sands and peats, the chief feature is Dairy Farming. The better soils in this district will fatten a bullock an acre, and keep two sheep in the winter; fattening of livestock is still carried on, although owing to the poor return from this, large areas have turned over to dairying which should be producing meat. Very little stock raising is carried on in this part of Somerset, due in some cases to the richness of the pasture, and in others to teart* land. In the southern part of this area are situated the majority of the withy beds in the county, but this industry is dying out.

North-East Somerset.—In the north-east of the county, adjoining Bristol and running down the east to the Mendip Hills, is another area which is devoted mainly to dairying and to a certain extent to the rearing of sheep. The soils here are very mixed, some on clay, others on gravel, whilst there are also thirsty stone brashes, sandstones and marls, and further south various types of clays and Green-sands. Along the south of the county are Green-sands and chalks with some very fertile and rich sandy loam. Here a certain amount of dairying and rearing of young stock is practised, and there are also some very fine mixed farms, roots, barley, oats and many other crops being successfully grown.

* See special article on this subject, p. 53.

South Petherton.—In the South Petherton area, stretching from Yeovil in the east to Ilminster in the west, and to Crewkerne in the south, is some of the finest farming land in the country. It is here that market garden crops are grown on a field scale, and heavy yields of potatoes, sugar beet, mangolds, carrots, parsnips, cabbage, wheat and barley are produced.

Taunton Vale.—Between the Quantocks and Brendon Hills, curving round the base of the Quantocks to Bridgwater in a thin strip, and running through Milverton and Wellington to Porlock in the north, are some very fine mixed farms producing the usual crops, but with barley as one of the main crops. Round Porlock some of the finest barley in the world is regularly produced; why, is not known, except that in this district the surrounding hills and sea give a very equable climate for the production of the best barley.

South-West Somerset.—In the south-west corner of the county, lying on the lias Green-sands and chalks of Chard, there is some very poor land, with a poorish type of farm. Dairy farming is again the chief feature in this area, with beans, mangolds and wheat as the main arable crops. In bygone days teasels were an important crop, but are now only to be seen growing on an occasional farm.

Quantock and Brendon Hills.—The Quantock and Brendon Hills lying on the Devonian formation are very similar in type of farming, mixed farming and the rearing of livestock predominating. On Exmoor similar conditions prevail, although altitude and climate somewhat limit type of crops—oats, swedes and turnips, with three to five years' grass seed mixtures being the main features. Water meadows are still common in the hill country where Exmoor sheep and Devon cattle are the main source of income.

Arable Crops.

For a county mainly devoted to dairy farming and grazing, the acreage of wheat is comparatively large, between twenty and thirty thousand acres being grown. Barley is grown on nine to twelve thousand acres, while the area under oats is approximately seventeen thousand acres.

Beans and peas are important crops, the latter especially in the Bridgwater–Taunton area, about twelve hundred acres being grown; they are mostly picked green in time for a catch crop of turnips, swedes or kale.

Many catch crops are grown, trifolium and vetches being the most important. These are folded off with sheep and followed by a root crop, in some cases mangolds. Even after winter oats or seeds hay, catch crops may be grown.

Generally speaking the arable land is clean due to early harvest and ample time for stubble cleaning.

Most of the rotations in the best arable areas (if they can be called such where so much catch cropping is carried out) are based on roots, corn, one year's grass and clover, corn, beans or peas, with market garden crops worked in where convenient. On heavy land, beans, wheat, one year's grass, wheat and probably bare fallow—two to three thousand acres being bare fallowed annually.

Orchards form a fairly large area, comprising some eighteen to twenty thousand acres and in probably no other branch of farming has science done so much to help the farmer.

LIVESTOCK.

Cattle.—The principal breed of beef cattle in the county is the North Devon, particularly is this so in the south and west of the county. This breed has been greatly improved in the last 100 years and combines hardiness, early maturity and quality of flesh to a high degree. It can live and put on fat on very bare fare, and is very suited to the conditions in large areas of Somerset. In addition to the North Devon there are a few scattered herds of Aberdeen-Angus, Hereford, etc.

About 90 per cent. of the dairy cattle kept in Somerset are Dairy Shorthorns—dual-purpose animals. There are also a number of Channel Island herds, a few good herds of Friesians and one or two herds of Ayrshires and Red Polls.

Sheep.—In the Exmoor district the old native breed is still to the fore, while on the other hilly country, Cheviot and Cheviot crosses are found on a wide range. Throughout the rest of the county, as would be expected, the Down breeds are to the fore, with the Dorset Horn a great favourite. The Dorset Down comes a good second and other breeds, such as Hampshire Down, Suffolk and Ryland are quite common.

The sheep population is much as one might expect, as flock owners of the county cater for the early fat lamb trade. It is evident from the flock owners' choice of suitable rams for the production of fat lambs, that they have made a study of this special trade, as even the Exmoor crossed with the right type of South Down ram can produce the right type of lambs.

Pigs.—Until recent years cheese-making was the chief outlet for the large milk production of the county, and from this one would assume that the pig population would be high in order to make the best use of the dairy by-products. Pig farming now holds a prominent place in the agricultural work of the county. With the pure

breeds, Large White, Wessex Saddle Back and Large Blacks and the resulting crosses forming the majority of the pigs in the county. The climate is suitable and outdoor pig feeding is practised, although with the great increase of pigs during the last few years, big modern houses of the Danish type have been built, and reconstructed from old factories and buildings in order to accommodate the increased production for bacon.

Horses.—Owing to the contour of the land and the large number of comparatively small farms, mechanization in its present form has not made any great headway, and the majority of motive power is done by horses, chiefly of the Shire type, although Percherons have been adopted in some parts.

Poultry.—As in other counties poultry has made enormous strides in Somerset, complete with Accredited Hatcheries, Accredited Poultry Breeding Stations and County Egg Laying Trials.

Dairying.

The milk and dairy industry is of outstanding importance, with Cheddar cheese as its chief product during the greater part of the year, followed by a fairly large output of Caerphilly cheese chiefly during the winter months, finding a market in the mining districts of South Wales. Since the introduction of the Milk Marketing Board, numbers of farms have given up Cheddar cheese-making and have gone over to the liquid milk trade; at the present time the industry is undoubtedly showing signs of recovery.

On the whole the farm buildings of Somerset are poor, merely because in such a county shelter for livestock is not so essential as in most counties of England.

The fields are scattered and workers go to the stock; rough shelters suffice, and milking in the open during the summer is still a feature of the county. The use of bails is very limited on account of the rainfall and nature of the soil.

Small Holdings.

As one would expect small holdings have been developed to a very great extent. The number of County Council small holdings is 1,175 with an area of 22,080 acres—20,157 purchased and 1,923 leased, the rent roll being £57,896.

Most of the men and their families on these small holdings seem to be able to make a living. The percentage of arrears of rent is a very small one, 2 to 3 per cent., which in itself gives some indication of the success or otherwise of the above venture.

A large number are dairy holdings, with the rearing of young stock as a side-line. Pigs and poultry are also another important side-line on these holdings, and in a number of cases form the main feature.

Agricultural Education.

The Farm Institute at Cannington seems to have fulfilled the suggestions made some eighty years ago. The outlook of farmers towards agricultural education has changed very considerably in recent years, particularly is this true of the younger generation. This is very strikingly exemplified in the growth of young farmers' clubs. The first club was formed in Somerset in 1930, in 1933 there were seven clubs in the county, and at the present time the number has increased to twenty. All the clubs in the county started as Calf Clubs, and all except one still keep calves. In several clubs, however, pigs and ewes are kept in addition to the calves. The great majority of calves reared are Dairy Shorthorn heifers, some however have preferred rearing Devon calves, and this year one club is rearing Dairy Shorthorn bull calves. As in other counties these clubs have instruction in the rearing and management of their stock and also in other branches of agriculture. One branch which seems very popular with most clubs is stock judging, dealing with most types of stock kept on the farm—cattle, pigs, sheep, horses and poultry.

Somerset is a very pleasant and comfortable county—steadily go-ahead would perhaps be the best way to describe it. Its people may be termed careful and comparatively slow to take up new ideas. However, once these ideas have proved successful they are not slow to adopt them.

THE AGRICULTURE OF NORTHUMBERLAND*

By Arthur R. Wannop

The most northerly county of England is one of the most varied. Stretching as it does from the Tyne to Tweed and from the North Sea to the summits of the Cheviots and to the Cumberland Border, the agriculture of the county is really highly diversified, and yet, no matter in what district of the county you travel, one fact is noticeable, that Northumberland is primarily a live stock county. It has been called England's premier live stock county, and there

* Paper read to Agriculture Committee, December, 1935.

is much to substantiate the claim. Other counties may surpass it in so far as one particular class of stock is concerned, but if regard be had to the production of beef and mutton on the average commercial farm, than the claim can almost certainly be justified.

The county extends to 1,284,500 acres, of which about one-half is mountain and heath land. Some of the latter is excellent sheep grazing but some is relatively very poor, and parts in the North Tyne are being afforested. Of the 650,000 acres returned as under crops and grass, just over 500,000 are permanent grass. A large proportion of this consists of secondary upland grazings, but some is extremely fertile land lying along the north-east coast and in the valleys of the Coquet, Wansbeck, Blyth and Pont, and forming excellent fattening pastures. The 140,000 acres of arable land are somewhat varied, but in the north of the county in Glendale and on Tweedside and in parts of the Tyne Valley, arable farming is practised. In the industrial area of the county which forms a triangle in the south-east, a considerable area of what would otherwise be good agricultural land has been ruined by the refuse heaps and subsidences associated with coal-mining, and has been rendered markedly sour by the fumes and smoke. With the electrification of many pits, farmers in their vicinity are tending to resort to liming and are turning some land to more profitable use.

The county has not always been so preponderantly under grass. In fact a marked feature of a surprisingly large number of the poorer upland grazings is the evidence of old-time ridge and furrow ploughing. Some of these are of extreme interest. In the Pont Valley, in particular, the ridges on some old pastures are extremely steep and deep. At one time the county exported considerable quantities of grain. Upland dales such as Allendale, now entirely under grass and exporting large quantities of milk, once grew wheat as a saleable crop. To-day it seems almost incredible that the small town of Allendale, now without a market of any description, once boasted a grain market.

The decline in arable farming in the county and the increase in permanent pasture is quite striking as the following figures show:—

	1873. acres.	1893. acres.	1903. acres.	1913. acres.	1923. acres.	1933. acres.
Corn Crops	144,000	97,000	85,000	77,000	70,000	50,000
Green Crops	61,000	49,000	44,000	40,000	35,000	26,000
Rotation Grass ..	88,000	87,000	72,000	60,000	71,000	62,000
Permanent Grass ..	359,000	472,000	502,000	519,000	481,000	510,000

The loss of almost two-thirds of the acreage of arable crops during sixty years is a very serious decline in the agriculture of

a county, and yet it has been more than offset by the enormous increase in output of live stock. Whilst sheep have shown a slight though steady increase and pigs have fluctuated both upwards and downwards, cattle have almost doubled their numbers. The actual figures are:—

	1873.	1893.	1903.	1913.	1923.	1933.
Cattle ..	98,000	109,000	117,000	134,000	132,000	178,000
Sheep ..	934,000	1,015,000	1,053,000	1,089,000	1,032,000	1,176,000
Pigs	15,000	10,000	11,000	10,000	14,000	12,000

This increase in the output of cattle and sheep has, of course, been partly due to the increase of permanent pasture but it is much more due to an almost unbelievable change in the character of many of the pastures. The work in turn of Somerville, Middleton and Gilchrist at Cockle Park in demonstrating firstly the great value of basic slag as a phosphatic fertilizer, and secondly the work that resulted in the famous Cockle Park seeds mixture provided the two main foundations upon which this improvement was built. Excellent natural pastures there had undoubtedly been before, but in the work of laying down land to grass and in improving the large stretches of what was once very moderate pasture the lessons that Cockle Park taught proved of inestimable value to the Northumberland farmer. Hundreds of acres of what was previously only suitable for store cattle became fattening grass with the stock carrying capacity greatly increased, whilst in the arable districts rotations were lengthened and the temporary pastures of to-day reach a very high level of productivity.

Sheep.

One cannot think of Northumberland farming without being impressed by the breeding and management of its sheep flocks. The 4th June returns show that in 1933 on just over one and a quarter million acres the county kept 1,176,000 sheep, or slightly under 1 sheep per acre. This is a high sheep population. What strikes one about the sheep flocks is their great uniformity both in breed and management.

There are only two hill breeds in the county—Cheviots and Blackfaces. The latter are of the Scotch type though in the south-west there is a very slight invasion of the Swaledale type of Blackface. As yet the invasion is more in the form of the use of a Swaledale ram on Scotch type ewes rather than a complete change of flock. The younger ewes are generally mated with rams of their own breed and the older ewes with a Border Leicester for producing first-cross lambs. There are hills, however, where all the ewes are

crossed. For mating with the Blackface ewe the South and West Northumberland breeders prefer a Border Leicester ram of different type from that used for Cheviots, the latter being the type familiar to Scottish breeders.

In the Hexham area of Northumberland there are many breeders of what is sometimes known as the "Hexham" or "Blue-skinned" Leicester. It is a Border Leicester with a dark skin similar to a Wensleydale, but free from the Wensleydale woolly forehead. Compared with the normal Border Leicester, it has less wool, a longer neck rather bare of wool, longer legs and a body less deep and less "muttony" in appearance. Like nearly every breed, it has suffered through breeding for fancy points and many of its breeders are to-day seriously alarmed at the loss of certain characteristics. Because of its localized breeding there has naturally been a considerable amount of in-breeding and the present flocks are by no means so hardy, nor such good framed sheep, as they were some years ago. They are favoured by the breeders of "Mule" or Grey-faced lambs because their off-spring have uniformly dark-coloured faces, and the ewe lambs are, it is said, more prolific and better milkers. The rams also stand the hill conditions better than the normal white-faced Border Leicester.

Though the table of live stock population of the county given above shows no increase in sheep population so marked as in the case of cattle, there have nevertheless been most marked changes in the class of sheep kept. Towards the end of last century the old wethers disappeared from the hills and the numbers of ewes gradually increased. The following figures are interesting:—

	1893.	1913.	1933.	Change in 40 years.
Ewes	374,000	438,000	489,000	+ 31%
Other Sheep—1 year and over ..	226,000	160,000	116,000	− 49%
Lambs	414,000	492,000	558,000	+ 35%

Even this table does not do full justice to all the changes. A bigger percentage of lambs are to-day marketed fat before the end of August than was the case even in 1913. It is interesting to notice also the increase in prolificacy. Whilst the ewes have increased by 31 per cent. since 1893, the lambs have increased by 35 per cent. An analysis of the figures shows that the percentage lamb crop is 6 per cent. higher to-day, and that for the whole county it is now about 115 per cent. It must be remembered that more than half the sheep in the county are kept under mountain or moorland conditions and that amongst these the lamb crop is usually about

90 per cent. or less. The general level of fertility amongst all flocks is thus fairly high.

Just as there is uniformity amongst hill sheep, so is there uniformity amongst the lowland sheep. The ewes kept on in-bye farms are invariably either Half-Breds or Greyfaces, the latter being known locally as "Mules." Farmers from the South visiting Northumberland comment freely on the fact that all the farms in a district keep the same breed of ewe. Especially is this the case in North Northumberland where the Half-Bred is universal. Bred from a Cheviot ewe by a Border Leicester ram, a Half-Bred ewe is exceedingly prolific, a splendid mother and nurse, hardy and very adaptable. On the best land she has no equal. In the centre and south of the county the Half-Bred *may* be losing ground to the Mule. On the low-lying good farms, especially where the land is dry and the rainfall low, the Half-Bred is usually kept, but on higher ground and in the wetter districts the Mule is the favourite. She falls little short of the Half-Bred in many respects. Scarcely so prolific, although on higher ground she does just about as well, she is on the other hand a more kindly mother and is freer from udder troubles and from scrapie. Her lambs, however, do not develop quite so well as those of the Half-Bred, and it is not so easy to find a suitable ram to cross with her to get lambs that hand.e well on the back. In bygone days, the Mule was always crossed with a Border Leicester, but mutton of that fatty type does not sell to-day. In recent years, Suffolks, Oxfords and Hampshires have all been tried, but the increasing favourite to-day is the Suffolk-Border Leicester cross ram.

CATTLE.

Just as there have been changes in the classes of sheep kept in the county so there have been interesting cattle developments, as the following table shows:—

	1893.	1913.	1933.	Increase in 40 years.
Cows and Heifers in Milk and in Calf	25,000	26,000	41,000	64%
Other Cattle—				
2 years and over	43,000	59,000	69,000	60%
1 year and under 2	24,000	29,000	36,000	50%
Under 1 year	18,000	19,000	30,000	66%

There has thus been a bigger increase in the summer fattening cattle—"other cattle, two years and over"—than in store cattle -"other cattle one year and under two."

Though Northumberland is foremost as a sheep-breeding county, it is not so important in cattle breeding. Of the large numbers of cattle fattened the majority are imported Irish stores, bought at such centres as Alnwick, Morpeth, Berwick or Hexham as well as at Carlisle. Most of these are Aberdeen Angus cross heifers, the number of horned cattle imported having decreased rapidly during recent years. The breeding of beef cattle within the county *is* on the increase, although there has been little encouragement of late for the store raiser. Galloway cows suckling blue-grey calves have long been a familiar sight on the high ground to the north and south of the Roman wall in the Haltwhistle district where the rainfall is high, but on the drier and better land to the north a good many Angus cross calves are now produced. The raising of home beef stores presents a problem. In bygone days many of the cattle fattened in the County were horned bullocks bred in the dales. Parts of the county, Allendale in particular, were noted for their dual-purpose Shorthorn cattle of the Cumberland and Westmorland type. Whilst butter was still the main dairy product sold these cattle were considered good milkers and they did produce good shorthorn bullocks. But with the entry of the farmers of these districts into the milk market ideas have altered considerably and with the demand for much higher milk yields, the old dual-purpose type has more or less disappeared, and the store bullocks now for sale from these herds are by no means popular with beef-producers. That it is possible to get back to the old dual-purpose type is doubtful even if it be desirable. The increased efficiency demanded of farming to-day involves some specialization of type and in any case true dual-purpose is not produced merely by crossing a beef-bull with a milky cow. Herein lies one of the biggest breeding problems north country farmers have to face.

The dairy cows of the county are somewhat varied. The majority are Dairy Shorthorns bred in the dales and in Cumberland and Westmorland. There are also a number of Irish heifers in many herds and an increasing number of Shorthorn-Ayrshire-cross cows are finding their way eastwards. Hexham is the principal market for dairy cows, and at the weekly sales there one cannot but notice the steadily increasing amount of Ayrshire blood represented. There are now a number of excellent herds of pure bred Ayrshires, and the number is likely to increase. Friesians also have their keen supporters but they are not likely to develop so quickly as their Scottish rivals. Herds of Channel Island cattle are few, but occasional Jerseys and Guernseys are found in herds of other breeds.

It cannot be said that Northumberland is by any means a pig

county. There is an extensive pork trade due to the industrial area, but feeding for bacon was rare before the advent of the Pigs Board. Now some farmers have added pig-breeding to their activities. Large Whites are the favourites, though where the pork market influences trade there is a good deal of Cumberland blood, and Large Black sows are quite popular also. In the same way poultry have only secured general favour with Northumberland farmers in very recent years, and the county is still far behind in its hen population.

Many contrasts could be drawn between different features of Northumberland farming, but space does not permit of their mention. Generally speaking the centre and north of the county are devoted principally to production of mutton and beef and the south and south-west principally but by no means entirely to the production of milk, whilst sheep-breeding is naturally predominant on the higher ground to the west and north-west. Possibly the two most interesting types of farming are the arable and semi-arable farms of Tweedside and Glendale, and the fattening farms lying between the Alnwick-Berwick main road and the coast.

Tweedside and Glendale Farming.

The district known as Tweedside embraces land both in England and Scotland and is one of the most noted agricultural areas of the British Isles. In general the farming is similar on both sides of the Tweed, though on the English side more cattle are fed and more hay is grown. The area is fortunate in its soil and climate, both of which allow great adaptability in regard to the proportion of grass, and permit of fairly regular yields of both corn crops and roots. Until comparatively recent times this North Northumberland district of lighter land was generally farmed on a four-course rotation, and was one of the last areas in the county to be compelled to reduce its corn-growing area. One of the most famous farms in the country —Wark—is situated in this area. It contains a very high proportion of the alluvial soil characterising many Tweedside farms, and has an outstanding record in regard to the production of crops and stock. At one time it was farmed by the famous and progressive farming family—the Culleys.

Most Tweedside farms are fairly large in area, varying from 400 or 500 acres up to 1,000 acres. In most cases the corn and root crops extend to from 20 to 30 per cent. of the area, the temporary grass to from 50 to 60 per cent. and the permanent grass to 20 per cent. or thereabouts. During the past two years the

arable area has been on the increase. The corn crops include oats, barley and wheat, and the root crops, swedes, yellow turnips, potatoes, sugar beet and kale. Wheat has increased since the Wheat Quota was introduced, whilst barley has been on the decline for some time. Sugar beet is now grown to the extent of some hundreds of acres and kale is a rapidly developing crop. The temporary pastures are certainly of outstanding merit. Seeds mixtures of the Cockle Park type are invariably used and with judicious manuring and grazing these leys can be maintained at their best for some time. Most of the land tends to be light, however, and in course of time Yorkshire fog appears and the time comes when the pasture will no longer fatten its due share of fat cattle and lambs. It has then to be ploughed out. The general custom is to plough out any field not maintaining its productivity, especially if near the farm steading, rather than to follow any strict order. On most farms, though there are wide variations, it is found that after eight years or so the pasture is definitely on the decline, as on Tweedside land it is extremely difficult, even under the best management, to keep out Yorkshire fog. Unless topping is carried out to prevent seeding it quickly ousts the better grasses and renders a field of very little value unless ploughed out.

Although the gross returns as between cattle and sheep may be fairly similar, the Tweedside farmer looks on sheep as the more important live stock. In this area the Half-Bred ewe holds undisputed sway. Her prolificacy, general hardiness, good milking qualities and adaptability make her suitable both for farms producing early fat lambs as well as for those rearing store lambs for winter fattening. The average lamb crop in this district is about 160 per cent. Oxford and Suffolk rams are generally used. The principal lambing takes place in March but on some farms older ewes commence in January so that some lambs may be fit for the Easter trade. It is customary for the main flock to receive only what grass they can pull up to Christmas, when hay may be introduced. Early in January roots in moderate quantity are usually provided and continued until, in February, the ewes may be folded on turnip land in order that the pastures can be cleaned to receive the ewes and lambs at lambing time. Ewes "on the break" are usually only allowed "on" for a few hours per day and are driven slowly off each night either on to an adjoining pasture or possibly on to part of the turnip field already cleared of roots. Here hay is provided. Some weeks before lambing is due to commence concentrates may be introduced, these being increased gradually until the ewes are brought into the lambing

field, where lambing shelters, usually of a temporary nature, have been erected.

The sheep stocking on Tweedside farms is high, usually one ewe per $1\frac{1}{4}$–$1\frac{1}{2}$ acres of the total farm acreage, and is such that after lambing the ewes and lambs must be spread over most of the pastures. On the northern side of the Tweed, in Berwickshire and Roxburghshire, first year's grass is usually grazed by young ewes with twin lambs, but in North Northumberland it is customary to take a hay crop during the first year of a new ley, and the various ages of ewes are arranged on the older pastures. The younger ewes with twins and any ewes with single lambs likely to get fat for the earliest markets get the younger and better pastures and lambs to be reared as stores for autumn and winter fattening are put on the older and less rich pastures. The summer stocking of most of the temporary leys in this area is very heavy, many fields being able to carry one ewe with twin lambs and almost one fattening bullock per acre.

Quite a fair proportion of the lambs are sold fat off the ewes during May and June and early July, the remainder being weaned in mid-July. By the end of August possibly 30 to 40 per cent. may have been sold fat, according to the season. The remainder are usually finished on grass with roots carted to them during the autumn or on the root break during winter and early spring.

Despite the fact that most of the land comes under the plough periodically there is considerable trouble with stomach and intestinal worms, and periodic dosing is a regular practice, usually with a 1 per cent. copper sulphate solution. Three or four doses at monthly intervals are given from the time the lambs are six to eight weeks old.

The change from arable farming to long leys has increased the cattle population of Tweedside and also resulted in quite a large proportion of grass fattening. There is, however, more winter fattening in courts in this district than in any other part of Northumberland. Nearly all the cattle fed are Irish stores of the black polled type. They are bought at various periods of the year according to the period at which they are to be sold fat. For grass fattening stores are brought during the autumn, wintered inside on hay and sold off grass from June onwards. This can only be done in this district on the better land. Farms on the outskirts of the area at a higher elevation and on lighter land cannot finish many of their cattle on grass. On such farms stores are often bought from January onwards, the courts being filled with these as fat cattle are sold. They are turned out to graze as soon as the grass is well grown,

and housed again in October, being finished on roots and kale, hay and straw, and concentrates. Whilst cereal prices are low, most of the oats grown are consumed at home. There are, of course, many farms on the best Tweedside soil, where both grass fattening and court fattening are practised. On many of the higher farms cattle-breeding is definitely on the increase. Aberdeen Angus—Shorthorn heifers are most favoured and are served with an Aberdeen Angus bull. The offspring are sold either as suckled calves or yearling stores, or if conditions are favourable may be kept until fat.

ALNWICK-BELFORD FARMING.

To the stranger the fattening industry of the Alnwick-Belford area may possibly be the most interesting section of Northumberland farming. Roughly speaking the area lies between the main Alnwick-Berwick highway and the sea, and stretches from the river Coquet northwards to almost Berwick-on-Tweed. To-day most of the area is under good grass consisting of some superior natural permanent pastures and of excellent long leys sown down in the early post-war years as the arable acreage was decreased. Unlike Tweedside these "temporary" pastures maintain their vigour well—they are, of course, regularly top-dressed with slag or North African phosphates, sometimes combined with potash—and retain their feeding capabilities in a most striking manner. The land is a heavy loam, and the large number of tower silos, now mostly out of use, in the area, is most striking and evidence of the difficulties of root-growing on this land in the days when the plough was going regularly. The grass herbage consists largely of Perennial Ryegrass and Wild White Clover, though other first-class grasses, like Cocksfoot and Timothy also grow vigorously. Plants of Yorkshire Fog are very few in number on the best fattening pastures. The predominance of Ryegrass and the absence of Yorkshire Fog may be partly due to two factors. Sheep are entirely secondary to cattle in this district and the best fields are not so heavily stocked with sheep, especially in spring as is the case on Tweedside. Secondly, the cattle are not turned out to graze on these fields until there is a good growth of spring grass. Both these practices allow the Ryegrass to gather strength in the early part of the season before it is called on to withstand heavy grazing.

The bulk of the cattle fed are Irish-bred Aberdeen-Angus cross heifers of the very best class. It is probably correct to say that the choicest cattle exported from Ireland to this country are consigned to the Alnwick district, and the weekly sale of Irish cattle at Alnwick is one of the market features of the county. The numbers sold each

week vary from four or five hundred up to almost two thousand, according to the season. These stores are about eighteen months old, and the feeders of this district buy nearly all their supplies during the summer months. The cattle are got into a forward condition before the grass season ends, and are then wintered inside more or less entirely on hay. When there is a good growth of grass in spring they are turned out and are ready for sale as prime fat heifers at the end of May or the beginning of June. On very many farms this is achieved without the use of any concentrated food, and is a feat of which many feeders elsewhere may well feel envious. Though of later years the number of bullocks grass-fed in this area as well as in the grass-feeding areas of the Wansbeck and Pont Valleys, has been on the increase, heifers are still the principal class of cattle fed, and a motor run through the area during the first week in June leaves a most striking picture in one's mind. Nearly every grass field carries its complement of one fat heifer per acre plus any extra sheep stock. A small number of select farms are reputed to carry one cattle beast per acre of the whole farm acreage each year. To see this district properly the visitor to Northumberland must travel by car and should leave the main road at Belford, keeping to the by-roads between the main road and the sea until he is twelve to fifteen miles further south. The number of right angle bends and narrow roads makes it anything but a motorist's paradise, but it is an experience worth having. I am often asked by those who pass from Berwick to Newcastle by train where the good land of Northumberland lies. It is true that this train journey gives a poor impression of Northumberland farming. Yet the northern part of this journey passes through the heart of the best grass fattening district, but from the train it cannot be seen properly. In fact to see the best of Northumberland farming in any part of the county, the traveller must not travel by train and he must leave the main roads if he is a motorist.

None of the other districts of Northumberland boast of a type of farming sufficiently unusual to merit special mention. There are large areas of grass where the feeding of Irish stores is carried on. Odd farms in these areas may emulate the Alnwick feeders with success, but there are no whole districts comparable to the area just described. As already suggested, there is a large amount of milk production. In the industrial districts, along Tyneside, and in Allendale, as well as in other districts lying to the south of the Tyne, the majority of farms sell milk either wholesale or retail. The south of the county is an area of smaller farms than is either Tweedside or the Alnwick district. In Allendale for instance, there

are very many holdings of the family farm type, or employing one or at the most two hired young men. So, although the area devoted to milk production may only be a small percentage of the land in the county, nevertheless out of approximately 4,000 farmers in Northumberland about 1,000 keep dairy cows and sell milk as a main branch of their farming. Official returns show 5,153 holdings over one acre in the county, but it is reckoned that 1,000 at least of these are of no agricultural significance.

AGRICULTURAL EDUCATION.

Agricultural Education in Northumberland dates back to before the establishment of Cockle Park in 1896, and yet its present-day organization, when viewed in the light of modern ideas, leaves much to be desired. Prior to 1896, Somerville had been giving occasional lectures in the county, and also doing extensive experimental work on grass and other crops. In 1896, the Northumberland County Council leased Cockle Park, and have maintained this experimental station as a county farm since that date. Within the last month or so a 999 years' lease has been agreed upon, and this should allow much needed improvements and developments to take place. Since its inception the farm has been directed on behalf of the county, and by agreement with Armstrong College, by the occupant of the Chair of Agriculture in the College.

For many years this was the only provision the county made for agricultural education. Sometime before the war an Instructor in Horticulture and an Instructress in Dairying were appointed, but in Agriculture proper any county work was undertaken by the Staff of the Agricultural Department of Armstrong College. It was not until 1924 that the county appointed an Organizer of Agricultural Education, to be followed in 1930 with the appointment of an Assistant County Organizer. Though provision had previously been made for instruction in Horticulture and Dairying, no provision was made, except for a few months in 1924, for instruction in Poultry-keeping until 1933. It seems strange that a county which was progressive enough in 1896 to establish Cockle Park should be so slow in developing county activities. The average expenditure on agricultural education involves a charge upon the rates of about $\frac{3}{8}$d., of which $\frac{1}{8}$d. is for the maintenance of Cockle Park, and $\frac{1}{4}$d. for general county activities.

Reference has already been made to the County Experimental Station—Cockle Park. Few experimental farms have influenced the farming of the locality in which they are placed quite so markedly. When in 1896 Somerville began his now historic experiment in Tree

Field, he laid the foundation of much of Northumberland's subsequent farming successes. But it would be wrong to ascribe the whole credit to Cockle Park. No small share is due to the Northumberland farmer himself. He is a keen stockman, with great skill and experience in stock management, well endowed with natural caution and yet with a progressive outlook and a keenness to examine up-to-date methods. Nor can any district boast of farm workers and shepherds who take a greater pride in their work. Mutual confidence in the experience and ability of each other makes the relationship between master and man in Northumberland an example to any district.

THE TEART PASTURES OF SOMERSET*

By W. R. Muir

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For nearly a hundred years it has been maintained that there are pastures in the central part of Somerset, on which cattle—and more especially milch cows and young stock—are liable to suffer from a distinctive type of scouring during certain seasons. Such pastures are described locally as "tart" or "teart."

The characteristics of this scouring which is said to occur on teart land would distinguish it immediately from most other types of scouring and would indicate that it has an uncommon cause. Thus, the scouring is persistent, and continues, usually with increasing severity so long as the cattle are grazing, but ceases almost abruptly when they are removed from the pasture and given dry food.

It would seem that the scouring can develop either on the first day or at any time up to six weeks after grazing commences, but usually, it is said to develop after eight to ten days continuous grazing. The dung becomes very loose and watery and consequently the animals get into a filthy condition. They soon lose weight, develop harsh staring coats and go out of condition altogether. All affected animals, however, seem to recover fairly rapidly if taken in immediately and given dry food; in practice, this is the remedial measure usually adopted, such dry fibrous foods as hay, straw and undecorticated cotton-cake being commonly fed.

* Paper read at P.R.C., Bristol, 1935.

All kinds of cattle are susceptible to the disease but milking cows and young stock are the worst sufferers, and the attempt is rarely made to rear the latter on teart pastures. The milk yield of affected cows falls rapidly and it is stated that these animals will suffer permanent injury if left on the pasture too long.

It is generally agreed that all the members of the herd are affected about the same time, but the resistance offered to the disease naturally varies with the constitution and condition of the beast. Fattening bullocks are, therefore, fairly resistant; nevertheless the fattening process is delayed and the animals would definitely "go back" if supplementary food were not given.

Although the disease can affect all breeds of cattle, the local opinion is that Ayrshires are the least susceptible and accordingly on teart farms there is a decided preference for this breed. It is stated that Red Devon cows when severely scoured change colour to a muddy yellow and this is undoubtedly true as the same colour change has been observed when red cattle have suffered from other forms of diarrhoea, but it is doubtful whether the colour change indicates the greater susceptibility of red cattle.

Horses are considered to be unaffected by the disease but their complete immunity has yet to be established.

The opinions of farmers differ as to the susceptibility of sheep. On the worst teart pastures, however, sheep definitely do not thrive and it must be concluded that they are affected in some way, although certainly not injured to the same extent as cattle.

Teart pastures vary considerably in their appearance, but as often as not they would be rated as good grazing lands. The degree of teartness is not always the same. It varies from pasture to pasture, from season to season, and from year to year.

It may or may not occur in May and June, but it is frequently present, and always at its worst, during the months of August, September and October; particularly in those mild, damp seasons when the aftermath is growing rapidly. In very dry summers, only a few pastures develop teartness. (This fact has repeatedly hindered investigators in their efforts to locate teart pastures because, curiously enough, it has usually been their misfortune to encounter dry summers.)

One of the few undisputed facts about teart pastures is that frost destroys teartness or decreases it so effectively that it is safe to graze even the worst teart pasture during the winter and early spring. Teartness also becomes less when the herbage is allowed to mature or to become "foggy." These facts naturally help to decide the grazing practice adopted.

Manuring very definitely increases teartness, and therefore beyond occasional dressings of lime, salt and farmyard manure, no fertilizers are applied to teart pastures.

Opinions differ as to whether hay from teart land has the property of scouring. When made green, it probably does scour slightly, but most of the hay is made from mature herbage and is well cured, and in this condition it seems to have very little effect. Most farmers agree that after one year in the stack, hay from teart land does not scour at all.

A singular fact about teart pastures is that they are found scattered among perfectly sound fields, and it is not common to hear of a farm on which all the pastures have the reputation of being teart. Sometimes a teart and a sound pasture may exist side by side and the boundary is sharp and distinct; whereas, at other times, there is a gradual change, possibly through a succession of fields, from sound to scouring land.

The conditions under which a pasture will possess the characteristic of teartness are not precisely known; therefore it has been a difficult matter to identify teart pastures and to decide their degree of teartness. Reputation has not always proved a reliable guide. Nevertheless, the limits of the teart area have been defined with a fair measure of success. Very roughly, the teart pastures may be said to lie within the triangle set by the towns of Shepton Mallet, Yeovil and Taunton, but, if the boundaries are traced more closely, it is found that they lie within and sometimes correspond in striking fashion with the boundaries of the Lower Lias formation. (For greater convenience this close association of teart pasture and Lower Lias will be considered later.)

Owing to the uncertainty with which some pastures can be specified as teart, an exact estimate of the total acreage of teart land is not possible at present, but as a rough computation, Gimingham has set down 20,000 acres for the area involved. However, the important fact is that the majority of the farms within the triangle mentioned above possess some teart pastures, and when it is pointed out that mid-Somerset is essentially dairy country, it will be realized that the presence of teart pastures on a farm may cause considerable inconvenience and loss.

Many avenues have been explored in the endeavour to explain the existence of teart pastures, and the soil, herbage and water supply have naturally fallen under the suspicion of most investigators while veterinarians have frequently endeavoured to trace the disease to parasites or to bacteria. However, in spite of repeated and sometimes laborious investigation, no solution to the problem has yet

been found. In view of this, it may be interesting to discuss the chief theories which have been put forward, especially as these theories have frequently determined the direction in which investigations have been pursued.

CAUSE OF TEARTNESS.

The cause of teartness has been attributed:—

(1) to bacteria; (2) to parasites; (3) to a particular herb or herbs; (4) to the water supply; (5) to poor drainage; (6) to the peculiar texture which is a supposed characteristic of teart soils; (7) to an unknown soil constituent which is taken up by the herbage and by percolating water.

It is extremely improbable that teartness is due to a particular bacterium or group of bacteria, otherwise the diarrhoea would be expected to persist, and perhaps, even grow worse after removal of the animals from teart pastures. Also there appears to be no tendency for the disease to be transmitted in the byre or when affected animals are transferred to safe land. It must be noted here that although the peculiar characteristics of teartness in cattle would distinguish the complaint from Jöhnes disease it is very probable that in the past, certain fields have received the reputation of being teart when the trouble has actually been due to Jöhnes disease.

Again, it is unlikely that teartness is due to parasites and for this conclusion the following reasons may be given:—

(*a*) No parasites have been found in affected animals and no ova detected in the faeces, although numerous post-mortem examinations have been made by veterinary practitioners.

(*b*) The typical disease is confined to moist autumn months and is not experienced during the early summer, even in seasons when the weather conditions are favourable, e.g., as in 1931.

(*c*) Two fields may adjoin and be under exactly similar management and yet one may be teart and the other non-teart.

(*d*) Teart fields are not heavily stocked, yet scouring will develop within a week on hay aftermath in a field which has been grazed with sheep during the winter and laid up in the spring without being grazed by cattle.

Teartness cannot be ascribed to any particular herb because repeated search has failed to discover any herb, peculiar to, or even

unusually abundant in teart pastures. *Linum catharticum*, which has been incriminated is certainly not peculiar to teart pastures, and by no means always present. It is impossible to discover a teart pasture by mere examination of the herbage. A field with a bad reputation may bear either a luxuriant grassy sward or a poor weedy growth, and in general botanical composition teart pastures exhibit no special differences from non-scouring pastures. Furthermore, repeated analysis has failed to reveal, so far, any abnormalities in the chemical composition of teart herbage; that is to say, the proximate composition is normal and no mineral deficiency or mineral imbalance has been detected.

The water supply has frequently been blamed for the scouring on teart fields. The supply may be derived from ponds, springs, rivers or public water mains. Ponds and springs charged with unusual amounts of aperient salts do occur on some teart fields, but the concentration of those salts is such that a cow will ingest daily an amount which is no more than half the corrective dose given in veterinary practice. Again, many fields are supplied with water from water mains or from geological formations other than the Lower Lias, yet none the less they are very teart. Teartness, therefore, cannot be a mild case of the disease which occurs on white alkali pastures in Southern Nevada, U.S.A.,[1] and all that may be concluded about the water supply is that in certain cases it may aggravate teartness.

Drainage is invariably poor on teart land and almost without exception the surface soil is a stiff, unyielding clay, overlying an even more tenacious clay sub-soil which is blue-grey or yellow in colour. In mechanical composition these clays differ in no marked respect from the clays on which scouring pastures do not occur. However, their peculiar close texture led Voelcker, and later, Gimingham, to conclude that this physical property was a leading factor in determining teartness, and since teartness is stated to decrease when the drainage and soil texture are improved, their conclusion appears to be justified. Nevertheless, soil texture and poor drainage cannot be accepted as agents directly responsible for the existence of teart pastures, as clays with the same close texture and impeded drainage, occur under non-scouring grasslands in many other parts of the country. Furthermore, one might expect these conditions to favour a distinctive type of flora rather than to change profoundly the character of herbage which normally does not possess scouring properties. One might expect also, that the disease will prevail in all wet seasons rather than be confined, as it is, to those wet seasons which occur in late summer. However,

it seems very probable that the close texture and impeded drainage have played a significant part in the development of teart soils.

THE LOWER LIAS.

It is now convenient to discuss the association of the teart pastures with the Lower Lias formation. This association was observed by the earliest investigators of the problem and later work has failed to establish the occurrence of teart land on any other geological formation. The worst teart pastures are undoubtedly confined to soils which are derived solely from Lower Lias clay. In Somerset, the boundary between Alluvium and Lower Lias is often very sharp and distinct, and by stepping across the boundary one can cross from sound to teart land. Indeed, Gimingham has stated that it is sometimes possible to trace the boundary merely by enquiring which fields are teart and which are not teart. Where this sharp boundary exists the Alluvium forms lands known in Somerset as "moor" land, and nearly all of it is liable to be flooded in winter. Moor land always yields mild pasture even when the tenacious blue or yellow lias clay is not far below the deposit of Alluvium. Pastures reputed to be teart have certainly been found on soils developed on the alluvial deposits of old river terraces, but these deposits are composed mainly of Lower Lias material, and blue lias clay lies within two feet of the surface. Moreover, these soils have developed under conditions of impeded drainage.

The boundaries between the Lower Lias and formations other than Alluvium, are usually not quite as sharp because drift obscures the Lias and therefore, except where the drift is very thin, it is found that teart land gives way to sound before the geological boundary is reached.

The striking and very pertinent fact about the Lower Lias in Somerset, is that it stands up unmasked by any other deposits except in a few scattered places where it is covered by alluvium, river gravel and boundary drift. Elsewhere in this country, the Lower Lias is covered by glacial drifts and beds of sand and gravel. Minor exceptions, however, are found where the Lower Lias forms small escarpments in Gloucestershire and Warwickshire, and it is precisely in these places where teart pastures again occur, although the scouring is reported to be less severe than that encountered in Somerset.

All pastures on the Lower Lias are by no means teart. Many are perfectly sound and, so far, this important fact has received no explanation. Better drainage could sometimes provide an answer, but not always, and present results would indicate that teartness

is not associated with any particular soil series developed on the Lower Lias.*[9] It may be that further investigation will show that the occurrence of teartness depends on the exposure of a particular zone of the Lower Lias formation.

However, in spite of some uncertainties, the unique association of teart land and Lower Lias would force the conclusion that the latter is directly responsible for the existence of teart pastures. It might be supposed, therefore, that this formation is unique in containing small but dangerous quantities of an element which is absorbed by plants, and which, by constant ingestion will finally produce super-purgation in cattle, but less serious symptoms in other livestock.

It is admitted that this theory does not fit all the facts; nevertheless, it is on lines thus indicated that the writer and his colleagues are pursuing part of their present investigations.

It may be noted with some interest here, that no report has ever been received of harmless land becoming teart, although the reverse has frequently been recorded, such changes having invariably followed drainage improvements and arable cultivations for a period of years. These facts would suggest that a toxic element is removed from the soil by percolating water and by crops carted from the land, while, at the same time, they would argue against the suggestion that teart disease is due to a mineral deficiency.

With regard to measures adopted for the purpose of converting teart land to sound pasture, only two have afforded any measure of success, viz., draining and ploughing. From the evidence available it does seem that efficient drainage has effected gradual improvement, but, on the other hand, ploughing-up and re-seeding have effected only temporary improvement and in the following years, teartness has gradually developed to its former intensity.

History of Teart Pastures.

Teart pastures must have existed for a very long time, but there is no mention of them in a report on "The Agriculture of the County of Somerset," made by John Billingsley to the Board of Agriculture in 1798, although the districts where the teart lands now occur was discussed at some length. However, a good deal of this land was under the plough at that time and the disease may not have occurred with sufficient frequency to merit serious attention.

The first mention of teart land appears to have been made in a prize report "On the farming of Somersetshire," submitted by

* A detailed soil survey of the Lower Lias in Somerset is being conducted by the Department of Agriculture and Horticulture, University of Bristol.

Thomas Dyke Acland (Jun.) to the Royal Agricultural Society in 1850.[2] In this report a brief paragraph was devoted to the teart pastures when the author was discussing the need for ploughing up poor grasslands. Before 1850, however, the teart lands must have attracted considerable attention and it was probably about this time that they were visited by Buckland and Lyon Playfair, who attributed the scouring to purging flax (*Linum catharticum*).

In 1855, a prize essay "On the Scouring Lands of Central Somerset" was submitted by Aubrey Clarke[3] to the Bath and West Society. Clarke, a land surveyor living at Street, near Glastonbury, Somerset, appears to have made a special study of the teart pastures and his essay provides a very complete and interesting account of them. Only one statement of importance is contrary to later experience, viz., the disease is worse in dry summers and mild during wet summers. This statement was, in fact, contradicted at the time in a note appended to the essay by G. S. Poole. However, Clarke argued soundly from his observations and concluded that "if experiments and investigations are directed to the discovery of a peculiar chemical combination in the herbage, the soils and the cold springs in the (teart) localities, there appears at least great probability that some light would be thrown upon the nature and origin of a mysterious complaint, which can be hardly considered yet to have obtained the attention and inquiry demanded by the extent of its practical, although local, importance." (It cannot be said that later investigators have advanced very far from the position in which the problem was left by Clarke.) In a further note appended to the essay, Lord Portman stated that he had "taken great pains to investigate the disease with the aid of a chemist, a botanist and the veterinary professor of the Royal Agricultural Society, but none could throw any light on the subject."

In 1862, Augustus Voelcker[4] reported on an investigation carried out at the request of the Bath and West Society. His report contains some interesting analytical data on soil and hay from both teart and non-teart land, and also on the mineral composition of water from Lias springs. However, the number of samples analysed did not justify the conclusions based on them and it is not surprising therefore that Voelcker's son was able to show later, that teart herbage does not contain an abnormal proportion of non-protein nitrogen.

A comprehensive series of experiments was carried out by the Bath and West Society[5] during the years 1896–1903. A bacteriologist and a veterinary surgeon were included among the investigators and experiments were conducted at three centres in turn, but for various reasons, no conclusive results were obtained.

Between the years 1908 and 1914, C. T. Gimingham[6,7], collected together valuable information concerning the teart pastures and carried out a number of experimental investigations. However, he was able to advance his conclusions no further than that the close texture of Lias soils was the leading factor determining teartness, and experiments designed to determine the effect of efficient drainage on teart soils could not be carried out owing to the lack of funds.

From time to time members of the veterinary profession have investigated the disease and they formerly held the opinion that it was due to parasitic infestation. The case for this opinion was stated by Penberthy[8] in 1894, but as he admitted, he had not visited the teart lands and his arguments were based mainly on information selected from the reports by Clarke and Voelcker. Veterinary officers of the Ministry of Agriculture commenced investigations in 1925 and from their observations concluded that the disease most probably arose from a chemico-botanical cause. However, negative results were obtained in a feeding experiment conducted with (reputedly) teart hay at the Research Laboratories, Weybridge, and the investigations were discontinued in 1926.

Since 1925, the Department of Agriculture, University of Bristol, has pursued a series of co-operative investigations and while it is hoped that the present investigations will lead to the solution of this very unusual problem, it must be admitted that two attempts to produce the disease by grazing animals on reputedly teart pastures have failed, presumably owing to the dry summers which intervened, and furthermore, no genuine case of teart disease has yet been obtained for post-mortem examination.

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AGRONOMY

COMPETITION BETWEEN SPECIES UNDER PASTURE CONDITIONS*

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The farmer's outlook on pasture has largely been dominated by the idea that pastures—good or bad—are inherited not made. This was due to the fact that the best pastures received no treatment, either in the form of cultivation, manuring or seeding, so that their quality was due simply to the soil.

During the last century, however, pasture in common with other crops came under the eye of the scientist, and was subjected to experiments. The first researches were conducted with manures, i.e. changing the amount of food available to the plants. This gave remarkable results, and particularly so when the balance of the various constituents were adjusted so as to correct any striking deficiency in any of the essential elements of plant food characteristic of some soils.

With the improved conditions in manuring, it was soon found that swards in which certain plants dominated, gave better responses to such improvements in the food supply. The logical conclusion was to have swards in which such plants were well represented, and with the agriculturist and scientist basing their inductions on their experience with the arable crops, the seeding for pastures came under investigation. Grass- and clover- seed mixtures were tested very thoroughly, and in recent years we find that even the best species can be improved upon, and in the hands of the plant-breeder great strides have been made in bringing out improved pedigree strains of the various species of pasture plants.

Various soils have different amounts of food supply, but with crops of a perennial nature such as pastures, nature has arranged that there should be an increase in the number of individuals in the flora up to the capacity which the food supply can maintain. The increase does not stop at that point; it goes on until there is a shortage of food, when there comes into play a competition for it.

* Paper read at Bristol, July, 1935.

If all plants were alike, they would each get the same share of the supply, and there would be no change in the botanical composition. The one thing that strikes the student of pastures, though, is the fact that it is very rare, almost unknown, to have a sward composed of merely one type of plant if that sward has been down for more than one season.

On the contrary, pasture plants differ very markedly in regard to several characters. In *form of growth* the range varies from the erect habit of the stem through wider and wider angles from the perpendicular until the truly prostrate form is reached. In *time of growth* we have, even in our temperate climate, as much as six to eight weeks' difference between the times that the earliest and the latest plants burst forth into active growth in the Spring. In addition, there is a big difference in the *rate of growth*—some plants, after being cut, recovering to a height of six inches in less than half the time of other types. These typical characters, if favourable, give the plant an advantage over adjoining plants in the competition. On the other hand, if the character is an unfavourable one, it sets the plant at a disadvantage with regard to its neighbours.

In an undisturbed sward the taller plants are favoured, whilst the fastest growing, and the earliest starting plants stand the best chance. In the process of grazing, however, all the plants are handicapped. The handicapper is the grazing animal: he is unfair, though not injudicious. He grazes the tall, erect plants because of easy access. He grazes the earliest because there is nothing else to graze at the time; and as he is only grazing to please himself, he tends to graze only the more palatable plants. As it happens, they are the succulent quick-growing ones. So it is not so much the intrinsic capacity for growth in a species that determines its success, but the degree to which it can tolerate the unfair handicapping.

In one experiment I subjected a sward, which had practically nothing but Perennial Ryegrass and Wild White Clover, to a series of grazing treatments, and observed the effect on the clover content. The grazing treatments consisted of subjecting various plots to a method of grazing with sheep, whereby the only difference between one plot and another was in the intensity of stocking during each month of the year.

This experiment showed that grazing fairly closely, without overdoing it, was the best method to encourage the Wild White Clover, and that March and April were the months during which this close grazing had the greatest effect. On the other hand, complete rest from stock in March and April enabled the early grass—Ryegrass—to attain such strength that under normal grazing from the end of

April onwards, this grass recovered so quickly after each grazing cycle that it allowed very little opportunity for the late prostrate clover to survive, leave alone spread. The experiment showed how very dependent the White Clover plant was on the competition which it had to face from the Ryegrass, and to what extent that competition between the two species was controlled by the grazing animal.

To know whether a species, or any particular strain of it, will thrive under pasture conditions, therefore, we must know three things. Firstly, how the plant would thrive if grown alone—i.e. whether the conditions of soil, climate and plant food are suitable. Secondly, how the plant would stand up to the repeated defoliation by the grazing animal; and the third condition, but one which can no longer be ignored, is how the plant would fare in the competition with the other plants that would survive the first two limitations.

Soil, Climate and Plant Food.—We know that adverse conditions in regard to either of these three factors will check the development of the plant, whatever the cutting treatments. On the other hand, if these environmental conditions are favourable, the plants will be the better able to survive under adverse cutting or grazing treatments.

Repeated Cutting or Grazing.—The effect of close grazing the grass in the Spring showed a distinct reduction in the yield of the plants during subsequent growth, and the next step was to ascertain the reason for it. This meant that as it was the part of the plant which was beyond the reach of the animal that was left to make the new growth, what required to be studied was the influence of cutting on that part—the root.

So the roots of plants subjected to various cutting treatments were lifted and compared, and it was found that severe cutting—hard back and often—reduced the root system very considerably. Where Ryegrass plants were cut back each week from Christmas to mid-April, the roots were less than half the size of the roots of corresponding plants left uncut, whilst the production of new leaves during the following month was also reduced in accordance with the root system.

Though any system of cutting back tends to check all plants by reducing the root, there are critical periods of the year when the same treatment has a bigger effect on one species than another. Thus removing all the green blades from Perennial Ryegrass and Cocksfoot plants each week from mid-January to the end of March, reduced the vigour of their subsequent growth much more in the Ryegrass than in the Cocksfoot, whereas the reverse effect was produced when such treatment was delayed until April and May, the Cocksfoot suffering worse than the Ryegrass. This showed the existence of critical periods of the year for each species, during which

time that species was more susceptible than its competitors to any ill-treatment.

The normal process of pasturing, however, is not altogether one-sided between the animal and the plant. Though the influence of the animal on the plant is adverse—at least during the greater part of the year—grazing being a process of robbing by defoliation, the plant is compensated to a very large extent by the animal supplying it with manurial ingredients in a readily soluble form. Under close grazing, therefore, there is a fairly quick turnover of the constituents through the plant and animal back to the soil in a moderately constant supply, and under such conditions Perennial Ryegrass benefits quicker than Cocksfoot. This may be summed up by saying that under good grazing conditions, entailing a continuous and rapid cycle of the constituents of plant food, Ryegrass increases more quickly than Cocksfoot, but under bad grazing conditions it also suffers more quickly than Cocksfoot.

DIFFERENCE IN INTENSITY OF GRAZING BY THE ANIMAL.

Now we come to the most important question of all: there is a difference in the intensity of grazing done by the animals under ordinary farm conditions when they have to rely upon the pastures for their keep all the year round. In the winter and early spring they nibble very closely for every green blade, whereas in the flush growth of late spring and early summer they have such quantities of food at their disposal that they never need graze any plant closely, and indeed the unpalatable plants not at all.

This enables the late starting and the unpalatable plants to gain entry into our pastures and eventually to dominate the pastures, much to the annoyance of the farmer, and indeed causing him a serious loss in the deterioration of such grassland.

This deterioration occurs in permanent pastures as well as in temporary pastures, and so effective is the control of the different species by the method of grazing practised that even when pure cultures of one species only are sown, they will soon allow the entry of volunteer plants to such an extent that the original species may soon be in the minority and even disappear if the management is unsuitable.

In conclusion, I will say that this competition between species is so dependent upon factors within the farmer's own control, that I venture to predict that before long the farmer whose land is mostly down to permanent pasture cannot afford to ignore the aspect dealing with the pasture itself, i.e. to carry on successfully he must consider the effect of his method of grazing on the pasture as well as on the animals.

THE SPREAD OF BRACKEN (PTERIS AQUILINA, L.) IN SCOTLAND AND ITS ECOLOGICAL SIGNIFICANCE*

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The bracken fern is not only widely known through Scotland, but is common in many parts of the world, while its past history goes back into geological times. There is no doubt about the increase of the areas of land occupied by this plant in Scotland. The increase and spread is not a recent occurrence, although it has lately shown a remarkable spread (Braid, 1934). In many old publications reference is made to bracken and the need for its destruction and control (Singer, 1807), (McTurk, 1837), (Murray, 1837) and (Macdonald, 1887). The increase of this plant is more evident in the West than in the East of Scotland. Since a large part of Scotland is uncultivated, and much of this is used for grazing, the economic aspect is most important. For some time now bracken has been steadily reducing the value of certain grazing areas, and so completely occupying others, that whole districts are now practically derelict. It is also invading young plantations.

There is little doubt that rather open woodland is the original home of bracken and that it has spread from woodland, and the sites of former woodland, to other parts of the country. This is largely true for England (Tansley, 1911), and woodland is probably its original home in Scotland. In many parts of Scotland it occupies the sites of old woodland. Where trees cast too dense a shade the plant becomes weakly and dies out. In Britain to-day it is frequent in oak and other woods. Where pine woods have been cut and replaced by birch there is always, sooner or later, a huge increase of bracken, which then spreads beyond the confines of the wood. It often follows where Birch has replaced pine (Smith, 1900), (Fenton, 1935). Scotland in the past had far more wooded areas than to-day, and with the destruction of these woods by man came the opportunity of bracken to spread. The Statistical Accounts of Scotland (1798, 1845) give several instances of the final destruction of many remaining woods.

This destruction of Scotland's woodlands has been going on over a long period. It began in Roman times, continued throughout

* Paper read to Biology Committee, July, 1935.

the Clan and Border Wars, the subjugation of the Highlands by Wade almost finished the destruction, which was continued intermittently till the cutting of timber during the war, 1914–1918 left many parts of Scotland almost without trees. This destruction of timber must have been a great stimulus to bracken development. Although spores are produced, yet in many parts they do not seem to aid greatly in the propagation of the plant (White, 1930). Hence it is that bracken owes its spread to the vigour of the underground stem or rhizome. Being underground it is not easy to destroy this perennial plant, and it is very well protected against damage, most difficult to attack, and very tenacious of life (Braid, 1934). It is capable of sending up fronds to replace those damaged or destroyed, while the frequent cutting necessary to check the plant is ample proof of its vitality.

Formerly many of the remote areas and the Highlands had a rural population. This population has long since dwindled and, for the most part, disappeared. Now this former population kept both cattle and sheep as well as the necessary quota of arable land. During this period bracken had definite uses. It was used for thatching, bedding for stock—and sometimes for man—and it was occasionally used for fodder mixed with hay, and sometimes for hay when cut early.* It is stated to have been used in brewing (Pratt, 1905). For a time it was used in the making of soap and glass, as well as for tanning (McTurk, 1857). It was tried unsuccessfully in paper manufacture. Commercial uses ceased with the progress of industry, but the depopulation of the Highlands was a different matter. Not only did the population go, but cattle also gave way to sheep. Then larger breeds of sheep replaced the native type (Watson, 1932). This meant not merely an economic but an ecological change. The old arable land was left, and bracken captured it with no resistance. From such favourable points it spread in all directions. The vegetation changed for the worse (Latham, 1883). Cattle by their heavier tread bruised and broke bracken, sheep avoided it and enabled the plant to spread (Smith, 1918). As pointed out by Jeffreys (1917) bracken is not readily capable of pushing its way below or through trodden paths—a rather important point. Sheep paths are not sufficiently consolidated but cattle paths are, so another hindrance to bracken development was removed. Rabbits also had matters much their own way and they are frequently blamed for spreading bracken (Horne, 1926, Farrow, 1925). They also turn up the soil and destroy the surface vegetation.

* Statist. Acct. of Scot. Vol. X., p. 354., 1845.

Cattle are general grazers and keep down the coarser material. Sheep are very selective grazers, and tend to overgraze the best vegetation till exhaustion begins and, along with *Nardus stricta*, bracken often enters these erstwhile good patches of grazing land. Differences in the nature and times of grazing—or lack of it—may cause very definite botanical changes (Fenton, 1927, 1932) (Martin Jones, 1933). The long continued grazing of sheep has already caused deterioration of many hill pastures by encouraging *Nardus stricta* (Fenton, 1933). Moreover, the continued removal of mineral material by grazing has in many districts so impoverished the feeding value that the number of sheep carried has seriously decreased, and losses in the flock have been very heavy (Orr, 1932). Since bracken has its rhizome much deeper than the roots of most grasses it can readily find a favourable environment in these exhausted areas, although the surface vegetation shows exhaustion of the surface layer of the soil. Added to this, the lack of attention to regular burning and control of heather areas has led to destruction or partial destruction of huge areas. There also bracken has successfully penetrated and is still spreading.

So far cutting has been the only method successfully applied on a large scale (Smith, 1928), (Braid, 1935). Solutions of sulphuric acid have been successfully applied in trials (Gordon, 1916) and more recently sodium chlorate has also met with success—at a price (Braid, 1933). It seems, however, that unless such methods are applicable over large areas, and at an economic price, little progress is likely in this direction. More recently special bracken-cutters (either motor or horse drawn) have been placed on the market and for certain types of land seem promising. Until more extensive use has been made of these new implements and more results are available, it is premature to speculate. In most areas of Scotland chain harrowing is not possible, and liming is not economic.

Biological control of bracken by pests has also, so far, failed. Both fungoid pests (Alcock and Braid, 1928), (Gregor, 1932), (Braid, 1934), and insect pests (Cameron, 1930) have been carefully investigated. Such destruction of bracken as occurs by either insect or fungus disease is of no practical significance except perhaps in some small restricted area. There is also some doubt as to whether bracken may not regain any ground temporarily lost by such causes. Hence, in our present state of knowledge there seems to be no natural parasite which takes a sufficiently heavy toll of this plant to keep it in check, much less to reduce its vast quantity. This has undoubtedly been a major factor in the extraordinarily successful progress of bracken.

Physical conditions may at times defeat the progress of this plant. The raising of the water level of the soil above a certain level undoubtedly is very detrimental to survival. This fact was seemingly recognized and made more use of in the past than at the present time; judging from the writings of McTurk (1837) and Murray (1837). On the other hand, the draining of certain parts has been blamed for assisting the plant to spread, but there seems little definite information on this point. On very dry soils which have also a rather dry subsoil, bracken does not show to great advantage, although a thin wiry sward may cover the surface soil. Such conditions or the making of such conditions, are only of local significance and quite inapplicable to large areas.

Perhaps the chief difficulty in this problem is that, within recent times, no useful and valuable outlet for the plant has been found. In past times it was used for manure (Pratt, 1905), and during 1914–1918 it was considered as a source of potash manure (Board of Agriculture for Scotland, 1917). In this respect, however, it cannot compete with the present commercial products. As a food for stock the rhizome is relished and eaten by pigs. They curiously enough, prefer to grub it up or to eat the rhizomes with the soil adhering to them, rather than eat it washed and cleaned (Hendrick, 1919). Sheep generally refuse to eat it, but its use for cattle is in some doubt. One fact seems to have been forgotten. Some time ago it was recommended for the making of silage for cattle by Macdonald (1887). A year later its successful use in this way, the method of making, and analysis, were given in the Chemists' Report of the Highland Society's Transactions by Dr. Aitken (1888). Since that time no further work appears on the subject. It most certainly deserves re-investigation. If sheep could be induced to eat such silage—and it seemed to compare very favourably with hay silage—then there are great possibilities for the future.

It is very obvious from what has been discussed concerning the spread of bracken and the activities of man that the whole problem is essentially ecological. Over a very long period man's activities, both direct and indirect, have assisted rather than retarded the spread of this plant. In the battle for the supremacy of many thousands of acres in Scotland, so far, bracken has had an easy victory. All recent efforts have failed to stem the advance much less regain lost territory, which suggests that restriction of advance is the most pressing problem. This might be achieved by treating the soil with a chemical poison in a narrow strip just outside the advancing line of the plant. If this can be successfully achieved then the regaining of lost territory can be considered later. The

most surprising fact is that the plant seems to have no serious parasite, and thus up to the present nature has not redressed the balance.

Assuming that bracken continues to grow for a very long period in any one place, what will ultimately replace it there? Every association of plants finally gives place to something else, but so far there is no information as to what might be bracken's successor or successors. If this were known it might be possible to speed up Nature and turn the advance into a retreat. When heather (*Calluna vulgaris*) gets old and opens up, rowan (*Pyrus Aucuparia*) and birch (*Betula alba*) often gain entrance and form a woodland association. Or, with suitable soil conditions and grazing animals, a grassland association may develop, the usual occurrence where bracken is repeatedly cut till exhausted. It may be that bracken will finally be replaced by woodland, which would be a just retribution on mankind. To a certain extent this may occur, judging by the inter-relation of certain associations given by Hardy (1906) some of which are from Smith's (1900, 1904, 1905) deductions. This question of ecological succession as it affects bracken requires further investigation.

The ecological aspect does not cease with the plant side of the question. This spread of a single species, amongst other plant associations, alters many other factors. Soil conditions, physical, chemical and biological are affected. The microflora and microfauna of the soil must be seriously affected. This also affects the surface life. Hence the present fauna of bracken areas must be different to the previous one. The insect life of the bracken "forest" must be different to that of woods, grassland, or heath.

Here the author might mention that in several parts of Devonshire (England), the insect life in bracken areas was both plentiful and vigorous, especially Cleg (*Hæmatopota pluvialis*, ♀) which at times made the life of beast and man almost intolerable. Was this just a local peculiarity or not? It is known that sheep struck by flies invariably hide themselves in bracken. In time, this is another point that may have great significance. How will vast areas of bracken affect bird life and that of ground animals? So far there seems little information on this point. Such problems, however, are of great importance. As the problem is an ecological one, no aspect can be safely ignored. A thorough investigation on the zoological side will be of great importance, and may yet aid to redress the adverse balance of factors at present favouring bracken in its disastrous spread.

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THE ECONOMIC POSSIBILITIES OF RICE GRASS (*SPARTINA TOWNSENDII*)*

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HISTORY.

Rice Grass was first discovered in 1870, growing at Hythe, on the edge of Southampton Water. From here it has spread by natural agencies to many of the mud-flats and estuaries along the south coast of England and north-west coast of France.

In 1881 it was recognised to be a distinct species and was named *Spartina Townsendii*.

In 1894 the suggestion was made that Rice Grass might be a hybrid between the European *Spartina stricta* and the American *Spartina alterniflora*. About this date another supposed hybrid

* Paper read in London, December, 1935.

between these two species was described from Bayonne in the Bay of Biscay. It was named *Spartina Neyrautii.*

S. Townsendii and *S. Neyrautii* have so many characters in common that, according to Stapf, "they could not stand as distinct species if one wished to leave the theory of their hybrid origin out of consideration." As to the latter, it is probably significant that they have both originated in the only two places in the world where both *S. stricta* and *S. alterniflora* are known to occur together. Whatever may be the position of *S. Neyrautii*, the supposed hybrid nature of *S. Townsendii* has been a subject of lively academic interest. It is, for example, the case that *S. Townsendii* breeds true from seed.

With a view to elucidating this matter further, Huskins, in 1929–30, carried out a cytological study of the three species concerned. He found that *S. stricta* had a somatic chromosome number of 56, *S. alterniflora* 70, and *S. Townsendii* a number equal to the sum of these two, namely 126, and concluded that *S. Townsendii* must have originated by chromosome doubling following on interspecific hybridization. Huskins' finding removed the difficulty in accounting for a hybrid breeding true from seed.

Nothing is known as to when or how doubling of the chromosome number occurred. The first record of *S. alterniflora* in Europe dates from 1803. *S. Townsendii* was not discovered until 1870. It might well be, therefore, that *S. Townsendii*, during its early years, was a sexually sterile 63-chromosome form propagating itself only vegetatively, and it is possible that this form may still be in existence.

Thus all the evidence supports the hybrid theory and the final proof will be forthcoming when *S. Townsendii* is reproduced artificially from its two putative parents.

Description and Habitat.

Rice Grass is a robust plant with erect stems two or three feet high and extensive, underground creeping stems. From both stems two kinds of roots arise; short, fine, much-branched nutritional roots forming a dense plexus near the surface and stout anchoring roots which descend vertically into the mud. Flowering begins in August and continues until January and sometimes later. The bulk of the seed ripens in November, the yield varying much with the season. The period of vitality of Essex seed is very short, extending to about 14 weeks. The rate of germination is good (up to 90 per cent.) in freshly gathered seed. Thereafter the rate declines rapidly.

The natural range of Rice Grass extends from the high-water mark of spring tides downwards to a level about six feet below that

line. Within this belt the upper regions are more easily colonised. The soil must consist of mud or clay or have these materials as a basis. Many of the mud-flats now occupied by Rice Grass have hitherto been quite bare. At the same time it has shown its ability to establish itself on and extend over those high level areas known as "saltings," which normally carry a mixed vegetation of Glyceria, Aster, Salicornia, Obione, etc.

Once established the rate of growth is rapid. From the initial point a plant may cover a circular area having a diameter of 3 feet in 3 years. The occupation of a new site may be hastened, and usually is sooner or later, by the dispersal of seed and fragments of shoots, although the risks in their case are very hazardous. In time, meadowing is completed by the plants growing together.

Two consequences follow. Firstly, the erect stems, by retarding the flow of tidal currents, cause material in suspension to fall to the surface, which thus is raised. Secondly, the growth of roots and underground stem knits together and so consolidates the superficial layers. As the level rises the plant maintains its place at the surface. This capacity to continue growth through an accreting soil is one of the most important possessed by Rice Grass, and is a feature of all the more useful coastal plants.

USES.

Coast Protection.

In 1925 experiments were begun in Essex to test the value of Rice Grass as an aid to coast protection. The coast-line of Essex is low-lying, long and sinuous, extending for about 350 miles. Most of it is protected from the sea by earthen sea-walls, the land behind being well below high-water mark. In front of these walls there stretch out great expanses of low-level mud-flats and high-level saltings. During high-water the sea plays continually on the walls with erosive effect. Occasionally the results are disastrous, as in 1928, when many acres of good land were inundated and lost.

Sea-wall maintenance is, therefore, a problem which is always with us, and it necessarily involves a considerable expenditure of money. From its already known properties Rice Grass offered a means of reducing this expenditure.

Our general aims were (1) to establish the grass on that part of the wall subject to contact with sea-water, and thus to prevent the surface being gradually washed away, and (2) to establish an extensive plantation extending outwards from the wall and so to raise the level and thus gradually exclude the sea from the wall as far as possible.

In many cases the experiments are proving eminently successful, although more time must elapse before the complete effect hoped for is attained. In others unexpected difficulties have arisen, the solution of which is still under investigation.

It was, of course, not possible to launch out from the beginning on a bold course of experiment on the lines indicated. Various sites had first to be tested as to limiting factors: the relative merits of planting by cuttings, seedlings and seeds investigated: the best time of year to plant established, etc. But, so far as coast protection is concerned, it seems clear that Rice Grass has come to stay. It is now, in fact, being used by various interested authorities not only in Britain but also in the Dominions and in many foreign countries.

Land Reclamation.

The most ambitious attempts to use Rice Grass as a means of reclaiming land from the sea have been made in Holland and Germany, but particularly in Holland.

Probably economic reasons rule it out in this connection in Britain, although we have no lack of apparently suitable areas, viz., in the Severn and Thames estuaries, on the north coast of Norfolk, in the Wash, the Humber, Morecambe Bay and the Solway; in Scotland in the Forth and Tay estuaries.

In Holland the operations were designed and carried out by Mr. A. G. Verhoeven, maritime engineer in charge of reclamations in Zeeland. As an engineer what has impressed Mr. Verhoeven is (1) the vigour with which Rice Grass has set about its task; (2) that it has quickly colonised soft, unstable barren mud, and (3) raised levels from 6 to 8 or even more inches per annum. He has written: "I think it (Rice Grass) of first-class importance for the rapid increase of cultivable land, if it is planted in the right places."

The first Dutch plantations were established in 1924–25 on the mud-flats on the south side of the Sloedam, which connects the islands of Walcheren and Beveland. Here the rise in level has been at the rate of about 10 inches per annum. When the maximum height has been reached the intention is to build a new sea-wall parallel to the Sloedam, thus cutting off the sea from the Rice Grass field which will then be brought under the plough.

Similar spectacular results have been obtained further up the Scheldt estuary at the Kreekrak Polder near Bergen-op-Zoom. The wall which brought the Kreekrak Polder into existence was built in 1921. In the first five years the rise in level by the old silting process amounted to about one foot. Rice Grass was planted

in 1926–28. Between 1926 and 1932 the measured rise in level was between four and five feet.

Rice Grass has, therefore, taken a conspicuous place in the technique of land reclamation as followed by the Dutch and has greatly accelerated that process.

Fodder for Stock.

Ample evidence has been accumulated to show that Rice Grass is readily eaten by grazing animals either cut green or in the form of hay and that they do well on it. So far as this country is concerned, its value in this connection would probably lie only in its use as an emergency fodder for those in a position to utilize it. In certain countries overseas, however, it appears to be not unlikely that Rice Grass may come to occupy an important position in the agricultural field, quite apart from proximity to the sea.

For example, plants were sent to New South Wales in 1930 to be grown as prospective fodder in the extensive salt lands of the Riverina district. The water supply for farm animals is taken from artesian wells and has a salinity of ·84 per cent. These wells produce a continuous flow of water which is said to destroy large grazing areas. The intention was to plant Rice Grass to receive the overflow from the artesian bores. The result has been quite satisfactory. A good rate of growth has been recorded, while sheep and cattle when allowed access to the plant ate it readily, and "seemed highly delighted." Cultivation is being extended.

Similar experiments are being made in South Africa, India and the Sudan.

VERNALIZATION: ITS MEANING AND PRACTICAL APPLICATION*

By G. D. H. Bell

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The Stimulation of Plant Development.

The word "vernalization" is the anglicized interpretation of the Russian word "Iarovization," which was originally used to describe the treatment practised on the grain of winter wheat that it might be successfully sown in the spring. True winter wheat when sown in the spring either fails to come into ear at all, or else

* Specially contributed.

it may throw up ears unevenly, and over an unduly protracted period. Vernalization causes the winter forms to behave as spring forms, for instead of growing vegetatively for a long time and producing large numbers of tillers which never elongate and produce ears, the vernalized plants pass into the shooting and earing stages without any check.

The principle of vernalization is based on the conception of the plant having to pass through various phases of development, each phase requiring a definite set of growing conditions for its inception and passage. No plant can complete its life cycle without passing through each phase in proper sequence, and development may be inhibited at various stages if conditions are unsuitable for the passage from one phase to the next. In the case of winter wheat, low temperature is necessary for the plants to pass through the early stages of ear formation in the young tillers before later development can take place. When winter wheat is sown in the autumn it is exposed to the necessary low temperatures, and can therefore pass into the later stages of development, which are induced by the higher temperatures and the longer days of early summer. But when winter wheat is spring sown it cannot develop beyond the vegetative tillering stage because it has not received the requisite exposure to low temperature. It has been discovered, however, that if the grain is moistened with about thirty-seven parts of water for every hundred parts of grain, allowed to soak for about twenty-four hours, and then exposed to a temperature just above freezing for at least 14 days, the plants will come into ear without further exposure to low temperature. This pre-treatment of grain which stimulates the reproduction of the plant is the original significance of the word vernalization.

Experiments on different varieties of winter wheat in various parts of the world have shown that the exact treatment to stimulate normal earing of these varieties when they are spring sown is a characteristic property of the variety. The most satisfactory results appear to be obtained when the moistened grain is exposed for 40 to 50 days to a temperature of 2 to 3° C. It is, however, of the utmost importance to realize that the response of any variety to a particular treatment will depend on the subsequent growing conditions, particularly the temperature during early growth. Therefore the time of sowing in the spring will affect the degree of earing-acceleration obtained by vernalization when compared with unvernalized plants.

Winter barley and winter oat varieties also have been found to respond to this low temperature treatment. Speaking generally

of winter cereal varieties, it seems a fair generalization to say that the more pronounced the winter character, the greater will be the responsiveness to vernalization treatment. Some workers also find that spring varieties of cereals will come into ear sooner when previously vernalized, but in the case of these spring varieties the exposure is for a shorter time, and the temperature is higher than is the case for winter varieties.

But it is not only low temperature which is capable of accelerating reproduction in plants, for other factors, and combinations of factors, have been found to be efficacious with plants such as cotton, potatoes, soya beans and millet. In some cases high temperatures exert a stimulative effect, while in others, various combinations of temperature and light exposure are necessary. The length of daylight exposure is extraordinarily potent in affecting the development of plants at certain stages, and exposure of soaked seeds to continuous light may have very material effects. Lack of appreciation of the fact that different species of plants require different vernalization treatments has led to considerable confusion in work on this subject. Every plant has to be studied carefully as it develops, and the environmental conditions noted as they stimulate the various stages. Attempts have been made to vernalize other species of plants by chilling, in the manner practised for wheat, when the plants required entirely different conditions. Such unsuccessful experiments have been taken as disproving the fact that artificial vernalization exists, whereas all they show is a lack of understanding of the interaction of the development of the plant and the factors of environment.

The numerous experiments which have been conducted on various methods of stimulating reproduction in plants have shown that other phases of the plant's growth can be markedly affected by pre-treatment of grain and seed. In many cases the young vegetative growth and development is affected, and acceleration in germination and establishment of the plants is very common. Vernalization has thus come to have a wider significance in relation to plant growth, for it is no longer confined merely to the effect on the onset of the flowering stage. In some cases the effect on the early vegetative growth of the plant is just as important as the effect on reproduction, and in cases where the plants are cultivated for the vegetative parts it is, of course, of greater importance. In considering the importance of methods of grain and seed pre-treatment, therefore, the whole life cycle of the plant must be studied, and vernalization, as the word is at present used, really signifies any developmental stimulation. It would probably be

more satisfactory to restrict the word vernalization to its original meaning and to talk about other aspects of physiological stimulation separately.

Practical Applications

Cereal Crops.

The possible practical application of seed pre-treatment will depend primarily on climatic conditions and the crops under consideration. Consider, for example, wheat cultivation, because wheat has been the subject of most experimentation. In 1934 it was calculated there were some 500,000 hectares (1,250,000 acres) of vernalized wheat in the U.S.S.R. which appears to be sufficient proof of the practical value of vernalization under certain conditions. This state of affairs is due entirely to the fact that there are large areas in Russia where there are no suitable varieties for cultivation under certain conditions which are not conducive to a high level of wheat farming, as, for example, in those areas where the autumn sowing of wheat is impossible or at best a hazardous procedure. Under such conditions it has been found that it is more profitable to sow vernalized grain of superior winter wheats in the spring, than it is to sow the local varieties of spring wheats. Again, there are large areas in wheat-growing districts in Russia where hot drying winds set in when the wheat crop is coming into ear, with a consequent reduction in the yield. Vernalized plants come into ear earlier, and escape the exposure of the young ears to those damaging winds, and thereby increase the yield. Finally, vernalization has been found to benefit the crop considerably in areas where early conditions of drought curtail the vegetative development of the young plants. Because of the quicker germination, better development of roots, and more rapid growth in the younger stages of the vernalized plants, they are better able to grow successfully under such conditions. Of course, it may be argued that varieties of wheat could be bred for such conditions. This is true and would undoubtedly be more satisfactory; but until the varieties are forthcoming, vernalization appears to offer some solution. This is particularly the case where the Russians are endeavouring to push wheat cultivation into the Arctic circle, for they find that by vernalization they are able to grow wheat in the short growing season of continuous daylight. Breeding wheat varieties for such conditions must necessarily be a long procedure.

Besides these major considerations where climatic conditions more or less determine the application of grain pre-treatment, there are others where the variety of wheat assumes a greater

importance. Thus, some varieties commence tillering earlier when the grain has been chilled beforehand, and tillering is more abundant. This is accompanied by a greater yield of straw and grain per plant in some cases, while the quality of grain may also be altered. Thus one observer records an increase in the yield of flour: an improvement in the baking estimation and texture of the loaves; and an increase in the volume of the loaves. This improvement in grain quality is, however, by no means a general characteristic of vernalized wheat, because in some cases the quality appears to have been definitely impaired. Effects of this kind are of more general interest and application, as also are the recorded effects of changes in susceptibility and resistance to diseases, than are the developmental effects which enable cultivation to be practised under certain adverse climatic conditions of a localized nature.

It is probable, therefore, that the pre-treatment of the grain of cereals has small possibilities for the agriculture of this country. It has been shown that the winter wheat varieties Joss IV, Yeoman II, and Rivett will come into ear earlier if they are chilled before sowing in the spring. Each of these varieties behaves characteristically, but each shows a greater acceleration in earing due to vernalizing the later it is sown. Vernalized Joss IV and Rivett, for example, come into ear about twelve days earlier than unvernalized, when sown on 29th March at Cambridge, but when sown on 8th March the vernalized plants were only two to three days earlier than the control plants.*

Spring sowing of wheat is rightly not popular in this country, and while there are suitable varieties of wheat for autumn sowing there is no application for vernalization in this respect. Where spring wheat is normally grown, or where autumn crops have failed, there is a possibility that vernalized autumn wheat may be superior to spring varieties or unvernalized autumn varieties. Work at Cambridge has suggested, however, that vernalization, although encouraging early tillering in spring-sown winter wheat varieties, tends to reduce the number of surviving ears at harvest. Unfortunately, it was found impossible to record the yields in these experiments, and there is no evidence available on comparative yields for this country.

The conclusion is, therefore, that unless vernalization confers some other distinct benefit it has no application for cereal-growing in England and Wales. The possibility of the quality being

* There is no particular benefit in the actual acceleration of earing. Unless the earlier earing is of direct practical importance to any cereal-growing areas of this country, this aspect of vernalization is unimportant.

improved in wheat and barley is worth consideration. Improvement of the quality of spring-sown wheat, if it could be effected economically and conveniently, might be worth studying; while the stimulation to early tillering and its effects on the malting quality of barley suggests itself as another line of inquiry.

Miscellaneous Crops.

Besides the work on cereal crops, that connected with forage plants appears to give promise of application to agriculture. Grasses, such as Meadow Foxtail, Cocksfoot and Timothy have increased their yield of green forage by 50 to 60 per cent., while in some cases acceleration in flowering has resulted from chilling the seeds. Leguminous forage plants like Red Clover, Lucerne, and Sainfoin have been similarly affected, accompanied by an increase in the number of stems and flower heads. The effect on the yield of forage, and also the probability of increased seed yield, is of great significance in these crops.

Many valuable horticultural and agricultural plants of a seasonal nature probably offer the greatest possibilities. Green peas for picking and canning, beans, lettuces, etc., are in this category. Reports of experiments with lettuce in Germany show that chilling the seed resulted in a marked increase in fresh weight and market value of several varieties. If the picking season for green peas could be lengthened by late sowings of vernalized seed there would be a considerable advantage to growers, but no work has yet shown this to be possible. Using controlled conditions in glasshouses a great deal might be done to force flowers and fruits out of season, or at any rate to lengthen the marketing season of perishable produce. Such a procedure would only be possible after much research work on the different species involved, in order to ascertain the right methods of stimulation.

Plant Breeding

In conclusion, attention should be drawn to the application of grain and seed pre-treatment to plant breeding. There is no doubt that the stimulation of plant development under controlled conditions of light and temperature makes it practicable to grow two generations in one year and thereby save a year in the raising of hybrid cultures. The most suitable time for this to be done would be in the winter following the setting of hybrid grain. First-generation plants could be brought to the grain-setting stage during the winter in hot-houses with special illumination. In the following year second-generation plants would then be grown instead of

first-generation plants, thereby saving a whole year compared with the normal procedure.

Here, at all events, is a practical application of vernalization which should be of distinct value in this country. Any possible means of reducing the time necessary for the breeding of improved varieties of crops is worthy of the considered attention of plant breeders.

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ANIMAL HUSBANDRY

DEVELOPMENT OF THE DAIRY HERD OF THE NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING*

By James Mackintosh

The aims which the Institute had in mind in forming a dairy herd were, firstly, to own dairy cows and to produce milk for the research work of the Institute and secondly, to build up a home-bred herd with good milking qualities, of good breed type with good udders and free from tuberculosis. It was decided that ultimately two breeds would be kept—Dairy Shorthorns because they were the chief breed on English dairy farms and Guernseys to represent the high butter-fat breeds of purely dairy type.

Possession was obtained of the farm at Shinfield in October, 1920. The farm buildings were poor and quite inadequate for the housing of a dairy herd, so only a few down-calving heifers were bought, but a considerable number of heifers and heifer calves were purchased during the next two years and reared to form the basis of a dairy herd when new accommodation had been provided. Progress was therefore very slow for the first three years.

The high price of stock at that time and the lack of money also made it impossible to buy first-class animals, and those bought were representative of the type of heifers and calves any ordinary farmer would buy. No pedigree females were purchased for some two years but a grading-up policy was decided on with a view to the ultimate development of a pedigree herd.

Sources of Purchased Stock—Dairy Shorthorns.

A number of in-calf heifers and younger stock were purchased in October, 1920, from the previous owner of the property; twenty yearling and two-year-old heifers were bought at a neighbouring farm sale later in the same month; ten heifer calves were bought as occasion offered during the winter; nine heifer calves were obtained from Wiltshire in the spring of 1921 and another six in the spring of 1922, and from 1921 to 1924 some 22 cows and heifers were purchased from the University Farm; these were surplus stock which Prof. Pennington was ready to sell and which I was

* Paper read at Bristol P.R.C., July, 1935.

ready to buy; lastly, four heifers were bought at different times from other sources.

In all, 85 cows, heifers and heifer calves were purchased, and the next stage in the development of the herd is to find out how many of these potential foundation cows are still represented in the herd and which of the various sources have proved most suitable.

In Table I, the sources of supply and their present representation (July, 1935) in the herd are set out.

TABLE I.

SOURCES AND PRESENT COMPOSITION OF THE N.I.R.D. HERD. DAIRY SHORTHORNS.

Source.	Stock bought. Females.	Stock at present. Families.	Cows and Heifers.
I. Cobham (1920) ..	14 heifers	5	12
II. Lucas (1920)	20 ,,	4	15
III. Bracknell (1921) ..	10 calves	0	0
IV. Wiltshire (1921–22) ..	15 ,,	3	9
V. S.R.W. (1920–22) ..	2 heifers	1	2
VI. J.E.G. (1921)	1 calf	1	3
	62	14	41
VII. Univ. Rdg. (1921–24)	22 cows and heifers (11 F.)	7	60
VIII. F.H.T. (1929) ..	1 heifer	0	0
Totals ..	85	21	101

The table shows that 62 females were bought from the first 6 sources, and of these only 14 now have descendants in the herd and these descendants number 41. From the University of Reading herd, 22 females, representing 11 families in that herd, were bought and of these 7 families are now represented in the N.I.R.D. herd by 60 animals. It appears, therefore, that 62 females from various sources have contributed 41 per cent. to the present herd, whereas 22 females from one source, where care had been taken in the selection of cows and bulls, have contributed 60 per cent. to the present herd.

PROGRESS IN GRADING-UP FOR COATES' HERD BOOK.

Only a small proportion of the 62 females purchased from sources I to VI qualified as Class A (foundation) cows, but those bought from the University Farm consisted mainly of animals in Classes C and D, and there were also five which were entered in the Herd book.

One other pedigree heifer was bought at a later date but she did not contribute to the maintenance of the herd.

The progress in grading-up is shown concisely in Table II.

TABLE II.

PROGRESS IN GRADING-UP.

	Grades bought.		Grades at present.		
	Sources I to VI.	Sources VII to VIII.	Sources I to VI.	Sources VII to VIII.	Total.
No grade ..	62	1	1	0	1
Class A ..	(9)	0	1	0	1
Class B ..	0	2	12	0	12
Class C ..	0	6	13	0	13
Class D ..	0	8	12	3	15
Pedigree ..	0	6	2	57	59
	62	23	41	60	101
	85		101		

Table II shows that at the present time, with one exception, all animals are in a grading-up class or are entered in or eligible for Coates' Herd book, and that the latter group comprises 59 out of 101. Of this 59, all are descended from University Farm stock, except two, which are descended from heifers purchased from sources I and II. A period of fifteen years breeding has been needed to grade up two calves for entry in Coates' Herd book. The age grouping of the present stock is (1) 37 cows in milk and dry; (2) 23 in-calf heifers, and (3) 41 younger heifers and calves.

The bulls used in the herd have all been carefully selected after a visit to the breeders' farms. The prices paid have not been high, ranging from 40 guineas to 75 guineas, with an average for six bulls of 55 guineas.

Guernseys.—The Guernsey section of the herd consists entirely of pedigree animals, and to form it two heifers were puchased in 1921 and six in-calf heifers were presented to the Institute by the English Guernsey Cattle Society in 1924. The present stock of Guernseys numbers 24 home-bred females, 1 old cow of the 1924 group and a few bull calves. All are descended from 5 animals—4 of the 6 presented in 1924 and one of the heifers purchased in 1921. The age-grouping of the present stock is (1) 20 cows in milk and dry; (2) 2 in-calf heifers, and (3) 3 younger heifers and calves. The small number of young stock is due to a large proportion of bull calves during the last two years and to another reason which will be referred to later. The bulls used have cost from £15 for a bull calf, up to

45 guineas for a yearling. During recent years the Institute has had the use of a well-bred bull of the May Rose family presented to the English Guernsey Cattle Society by an American breeder.

Milk Yields.—The success which has attended the efforts to breed a herd of good milkers is probably best shown by Table III, which shows the average yield year by year for the full-year cows according to the records checked by the Berkshire Milk Recording Society. The yields of the Shorthorns and the Guernseys are shown separately and also the average yields of the herd as a whole.

TABLE III.

SUMMARY OF ANNUAL MILK YIELDS OF FULL YEAR COWS.

Year.	Shorthorns. No. of Cows.	Shorthorns. Aver. Yield. lb.	Shorthorns. Aver. Fat %	Guernseys. No. of Cows.	Guernseys. Aver Yield lb.	Guernseys. Aver Fat. %	Total. No. of Cows.	Total. Aver. Yield. lb	Total. Aver. Fat. %
1921–22 ..	7	7,158	—	1	4,529	—	8	6,856	—
1922–23 ..	11	5,159	—	1	5,033	4·95	12	5,148	—
1923–24 ..	16	6,986	—	1	6,346	4·84	17	6,949	—
1924–25 ..	21	6,976	3·76	4	5,826	4·82	25	6,792	3·90
1925–26 ..	19	7,291	3·79	6	5,834	4·92	25	6,941	4·00
1926–27 ..	24	8,549	3·71	4	7,250	4·73	28	8,363	3·84
1927–28 ..	22	8,820	3·78	6	7,841	4·94	28	8,610	4·00
1928–29 ..	24	9,474	3·84	5	8,684	4·84	29	9,337	4·00
1929–30 ..	31	8,305	3·68	3	6,889	4·58	34	8,180	3·75
1930–31 ..	31	8,371	3·76	8	5,409	4·73	39	7,763	3·90
1931–32 ..	26	9,117	3·69	7	5,735	4·59	33	8,400	3·82
1932–33 ..	32	7,572	3·76	7	6,432	4·83	39	7,367	3·92
1933–34 ..	25	7,355	3·57	8	6,443	4·52	33	7,134	3·78

During the early years the rate of improvement was slow because so many of the animals bought as heifers and calves turned out to be poor milkers. The low yield in 1922–23 was due to the removal of several cows which failed to pass the tuberculin test. Real improvement became evident in 1926–27, when home-bred cows were in their second and third lactations. The decrease in the average yield in the last two years is due to the disposal of a number of good-milking old cows, the failure of a number of younger cows to attain a high yield and the sale of several good cows which had aborted or reacted to the agglutination test.

Improvement in Breed Type.—A large proportion of the heifers and calves purchased from sources II, III and IV grew into very plain animals, some with definite evidence of a mixture of breeds in their ancestry. When these were disposed of and replaced by home-bred stock a marked improvement was noticeable and in

1926–27 and later years, there was some satisfaction to be derived from an inspection of the herd.

The general standard of the herd as regards breed type and uniformity (and also milk yields) is best indicated by the degree of success attained in the "Large Herds" competition of the Berkshire Milk Recording Society from 1926 to 1932. This is as follows: in 1926–27, 7th place in 11 entries; in 1927–28, 2nd place in 6 entries; in 1928–29, 1st place in 7 entries; in 1929–30, 2nd place in 4 entries; in 1930–31 not entered, and in 1931–32, 1st place in 6 entries. In 1930 also the herd was placed second in the Open Class of the Royal Counties Agricultural Society's Herd Competition. In this Competition no points were awarded for milk yields.

These results show the degree of success attained more conclusively than the exhibit of a few selected animals at shows, but there is still room for improvement in Shorthorn character and colour.

Freedom from Tuberculosis.

In making the original purchases no attempt was made to get animals which had passed the tuberculin test then in general use—the subcutaneous test—with the exception of the animals bought from the University Farm. This herd had been regularly tested since 1909 and there had been only one reactor from 1912 to 1928.

Systematic application of the tuberculin test to the Institute stock was begun in 1922 and spring and autumn tests have been carried out each succeeding year The results of each test are set out in Table IV.

TABLE IV.

TUBERCULIN TEST RESULTS IN THE N.I.R.D HERD.

Year.	No. Tested.	Failures.	Year.	No. Tested.	Failures.
1922	63	10	1929 ..	55	2
1923	28	3		58	0
	32	1	1930 ..	48	1
1924	47	2		49	1
	57	1	1931	57	0
1925	38	0		85	3
	39	1	1932 ..	58	0
1926	41	0		92	3
	72	0	1933 ..	59	0
1927	45	0		83	0
	68	0	1934 ..	65	0
1928	49	1		131	0
	67	0	1935 ..	138	2

In May, 1923, a Grade A (T.T.) licence was obtained.

After 1924 no more females were added to the herd, except in 1929 when one pedigree Shorthorn heifer was bought. This heifer reacted in March, 1930, but had been kept in a box by herself from the time of purchase.

It will be noticed that usually more animals are tested in the autumn than in the spring. This is because it has been the custom to test all heifers before service, so that only heifers which had passed the test would be brought in close contact with the milking herd. The animals which have failed to pass have usually been heifers under the age of four years; of the total number of 31 animals disposed of because they failed to pass the test, 17 were bought, and 14 were home-bred; also 9 had not had a calf, 10 had had one calf, 7—two calves, 2—three calves, 2—four calves, and 1—five calves.

As a rule, therefore, cows which have had more than two calves have continued to pass the tests each year. It has not been our experience that the best milkers have failed to pass; on the other hand, I believe that in a clean herd, good milking cows have a better chance of a long, productive life than in an untested herd.

In the autumn of 1934 all stock over the age of one month were tested and all passed, hence an application for "attestation" was made in February, 1935, to the Ministry of Agriculture. The official tests carried out by the Ministry's Veterinary Officers resulted in two animals (a 5-months'-old calf and a 2-year-old heifer) being described as reactors and two others as doubtful. The reactors were disposed of and the doubtfuls have since passed the double-intradermal test.

In spite of this disappointment, we have not encountered any serious difficulties in maintaining a herd almost, if not entirely, free from tuberculosis during the last twelve years.

Contagious Abortion.

I have referred to contagious abortion as one of the causes of the decrease in yields in 1934; it is also the cause of the small number of Guernsey young stock and I must deal with this question more fully as it now constitutes our main problem in herd management.

Up to the late summer of 1933 we had had no cases of contagious abortion. From 1922 to 1933 we had occasional cases of abortion, but in every instance blood samples were taken and gave negative results.

In the autumn of 1933, blood tests following some three cases showed positive results and other four cases of abortion occurred in November and December. It was then decided to do blood tests

monthly and attempt to eradicate the disease by segregation and disposal of reactors. This policy was continued until August, 1934, and by that time 15 cows had been sold.

In September and October, 1934, there was a marked increase in the number of positive cases, and it became impossible to continue the sale policy. Since that date an attempt has been made to segregate the positive and negative cows as fully as is possible on one homestead. The results have been disappointing and at present there are some thirty-seven cows positive and twenty negative to the blood test. All in-calf heifers are at present negative.

Systematic blood testing has enabled us to a large extent to control the *place of abortion* and will be continued. Unfortunately, we have had a number of cases where the cows gave negative blood tests up to the time of abortion and the value of a segregation policy has been thereby lessened.

The breeding programme has been seriously upset and the use of the herd for other experimental work has been greatly interfered with, but we intend to pursue the blood-test and segregation policy and to keep the majority of the positive cows for breeding purposes for some years.

THE FERTILITY RATES OF SOME WEST COUNTRY BREEDS OF SHEEP*

By J. F. H. Thomas

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In the handbook *British Breeds of Livestock*, published by the Ministry of Agriculture and Fisheries, there is a relative absence of specific references to the fertility rates of the 30 odd breeds of sheep described; in fact, only in the case of two types, the Suffolk and the Half-bred, are any figures given to illustrate their potential breeding capacity.

The problem of fertility in sheep is one of great complexity. In the first place, the term "fertility" is loosely applied. The flock-owner is more interested in the actual number of lambs reared than in the number born; yet obviously the number of lambs born (alive or dead) is a truer measure of fertility than the number of lambs reared, because the incidence of some post-natal causes of loss may

* Paper read to Agriculture Committee, July, 1935.

be heavy. The collection of reliable data from flockowners is not easy because it is very seldom that the actual birth rate is recorded. Hence the investigator of sheep fertility problems is usually obliged to accept figures which actually represent the rearage of lambs—or "lamb crop."

Then there is another difficulty of major importance—environment has such a potent effect on fertility in the case of sheep, and when a particular type of ewe is kept under a wide range of environmental conditions, great variations inevitably occur in potential breeding capacity.

Again, the constitution of a breeding flock in respect of the age of ewes bred from has a marked influence on the fertility rate, since during her first two breeding seasons a ewe does not usually attain her maximum breeding capacity.

Despite these difficulties, in a publication of the Bath and West Society entitled "The Sheep Farming of South-West England," I have ventured to suggest Fertility Rate Standards for the types of sheep to be found in the mid-Southern and South-Western Counties.

I will summarize the breeds under the headings Indigenous and Imported.

Indigenous.	*Imported.*
Hampshire Down	Southdown
Dorset Down	Suffolk
Dorset Horn	Kerry Hill
Oxford Down	Half-Bred
South Devon Longwool	Cheviot
Devon Longwool	Blackface
Improved Dartmoor	Ryeland
Devon Closewool	
Exmoor Horn.	

Arranged in order of fertility rates, the above 16 breeds fall into three groups which I will term High, Medium and Low Fertility groups.

High Fertility (over 130 lambs per 100 ewes mated). Half-bred Dorset Horn, Oxford Down, Suffolk.

Medium Fertility (110–130 lambs per 100 ewes mated). South Devon Longwool, Devon Longwool, Improved Dartmoor, Kerry Hill, Devon Closewool.

Low Fertility (under 110 lambs per 100 ewes mated). Exmoor Horn, Dorset Down, Hampshire Down, Southdown, Ryeland, Cheviot, Blackface.

The above classification is only intended to apply in the case

of flocks which are kept under what may be best termed "average conditions" for each particular breed.

Now I wish to show in the case of certain breeds, the extent of variation in the fertility rates (or rather the lamb crop) that can be found between individual flocks.

In the case of the Hampshire Down, in 30 flocks totalling over 10,000 ewes, the average crop is 112 lambs per 100 ewes mated, but the highest return is 127 lambs per 100 ewes and the lowest is 90. Similarly in the Dorset Horn breed, 21 flocks totalling over 6,000 ewes, show an average crop of 130 lambs per 100 ewes, but the highest individual return is 150 lambs per 100 ewes and the lowest is 120. Again, in the case of the Exmoor Horn, for which I have an average figure of 116, one small flock, kept under exceptional conditions gave 140 lambs per 100 ewes mated.

What are the major causes of these considerable variations? This is an easy question to answer. When one studies the question under field conditions, the most striking fact is the great variability to be found in the efficiency of those who own and care for sheep. I venture to suggest that there is more lack of skill in the tending and management of sheep than there should be. A flock of a type potentially prolific can yield,—and I have many examples of this—a disappointing lamb crop, mainly owing to inefficient husbandry.

But even when management is sound, and losses of ewes and lambs are reduced to an absolute minimum, one finds that a certain type of ewe will exhibit different degrees of potential fertility—by this term I wish to imply the total birth rate (live and dead). The influence of environment, particularly food supply, is greater than many flock owners are prepared to admit, but those who have had experience of breeding from ewes of Mountain, Hill, or Moorland breeds—under Lowland conditions—are fully aware of the greatly enhanced breeding capacity which results from keeping ewes on a higher plane of nutrition. I want here to make the positive assertion that the practice of "flushing" does not play a very important part in increasing the birth rate, though I admit that it tends to shorten the period over which matings take place, and this is highly desirable. When I refer to "flushing" I mean the *short* period of high feeding before the rams are turned out. Some of the most prolific ewe types that I have studied have never been subjected to the practice of flushing. (Here I would like to state that from 50 ewes—Half-bred, Kerry Hill and Suffolk cross—I have reared 90 lambs on one of the College farms during the present year.)

Fundamentally, the birth-rate is determined by the rate of ovulation, and the development of ova in the ovary is not a rapid

process. Long periods of low feeding after the lactation period is terminated can result in a scarcity of follicles to be brought to full maturation during the process of "flushing." In part, the low fertility rate of the Hampshire Down is due to the fact that on many farms the ewes have a bare subsistence diet during the period between weaning-off the lambs and subsequent mating. Such ewes are very bare in condition when their lambs are weaned and sometimes even barer when they go to ram in August and September.

Again, in the case of the Half-bred, the fertility rate in counties such as Wiltshire and Hampshire is seldom equal to that of Half-breds kept on Half-bred farms in Northumberland. I can account for that by pointing out that many Half-bred ewes on the Southern Chalk uplands, are kept under what I would term "Cheviot" conditions.

The fertility rates of the West Country Longwools, The Devon Longwool, the South Devon, and the Improved Dartmoor—the latter by the way must no longer be regarded as a Moorland breed—are relatively low, considering that ewes of the above breeds are usually kept on productive land. In this case, I suggest that each of the above breeds is suffering from excessive in-breeding, and that is why I have suggested that they should be amalgamated to form one breed of West-Country Longwools. Some commercial flocks to-day in Devon and Cornwall consist of crosses between each of the above breeds, and it is claimed that these Longwool cross-breeds are more fertile.

The majority of pedigree Oxford Down flocks in Gloucestershire show very high fertility rates (140–150 per cent.) This I attribute mainly to the fact that they are kept by owners who specialize in ram breeding and the efficiency of management is very high.

In conclusion, I want to point out that there is a definite association between worm infestation in breeding ewes and their reproductive capacity. Ewes which are suffering from reduced vitality through carrying an excessively high infestation of internal parasites, cannot be expected to produce a maximum number of ripe ova for fertilization, since the functional activity of their ovaries will be adversely affected.

NUTRITIONAL ANAEMIA IN PIGS*

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Most farmers who have reared their own pigs are aware of a troublesome condition which sometimes occurs among pigs of about 4 to 6 weeks old. This condition is characterized by paleness of the skin, drooping ears and tail, and, in the later stages, is accompanied by rapid breathing. The disease is commonly known in Ireland as "Blows" or "Thumps." The losses due to Blows can be severe, and there is little doubt that such losses contribute largely to the high death rate so common among pigs between birth and weaning.

Systematic work on this disease was initiated in this country only some ten or fifteen years ago, but the experiments of McGowan and Crichton[1] in this country and of Doyle,[2] Hart[3], Hamilton[4] and their co-workers in America have shown quite definitely that the primary cause of "Blows" is a simple nutritional anaemia due to lack of iron in the sow's milk.

Present day methods of pig housing and management seem to have brought about an increase in the incidence of anaemia in young pigs. It is more than probable that under former less hygienc methods of management the young pigs were able to pick up sufficient iron from the sow's manure or the surrounding dirt to meet their needs. Nowadays, however, there is a tendency towards keeping pigs under more intensive conditions. This has necessitated better buildings with impervious floors which can be readily cleaned. Moreover, where a large number of animals are kept under restricted conditions, there is the ever present risk of spreading disease. For this reason it is sometimes impossible to allow young litters to range over land near the farrowing pens for fear of infecting the young pigs with worm eggs and parasites. Thus we are sometimes driven to the necessity of keeping young pigs in the farrowing pen until they are weaned.

Some three years ago new piggeries were built at the Agricultural Research Institute at Hillsborough. These included a farrowing house which would accommodate some twenty sows and their litters. It was not possible with the site available to provide outdoor exercising pens for the litters and it was not long before there were obvious signs of the development of anaemia among the young pigs.

* Summary of paper read at P.R.C., December, 1935.

This was confirmed by the estimation of the haemoglobin-content of the blood of the young pigs, when the blood haemoglobin was found to have fallen to about a quarter of the normal value. It was necessary, therefore, to find the most convenient and practical method of introducing iron into the diet of the young pigs. We offer this account of our trials, not because they cover new ground, for Hamilton and his colleagues have already published[4] results of similar trials, but because we thought that perhaps it might prove interesting to hear the results of trials carried out under our conditions.

When the trouble first appeared an attempt was made to overcome it by using the method advocated in Denmark, namely by dosing each individual pig affected, two or three times a week, with a teaspoonful of a dilute solution of ferrous sulphate. This did not prove altogether satisfactory in practice for two reasons. In the first place, the Danish method not only takes a fair amount of time but also involves handling the pigs, an objectionable practice with young pigs. In the second place, the use of iron sulphate solution led to constipation except where the greatest care was exercised in graduating the dose.

Early in 1934 a series of controlled experiments was carried out with a number of litters from gilts which had all been brought forward under the same conditions of management. After service they were run out on grass and fed the following ration:—

	Parts by weight.
Bran	10
Pollards	35
Maize meal	40
Flaked maize	10
Extr. soya bean meal	5
High grade meat meal	2
Mineral mixture	2

A week or ten days before farrowing they were brought in to the farrowing house at night. They were farrowed in a farrowing crate. A few days before farrowing the ration was gradually changed to the nursing ration, which was as follows:—

	Parts by weight.
Bran	20
Pollards	25
Maize meal	30
Flaked maize	10
Extr. soya bean meal	7
High grade meat meal	5
Mineral mixture	2

When the litter was about three weeks old, the sow was removed for increasing periods so as to encourage the young pigs to eat solid food. The various iron treatments used are shown below:—

TREATMENTS.

(1) Teats of sows "painted" with iron solution twice daily for five weeks and young pigs received ·1 per cent. iron sulphate in food.

(2) "Painted" with iron solution for five weeks. No iron sulphate in food of young pigs.

(3) Not "painted" but pigs to receive iron sulphate in food.

(4) Control. Not "painted." No iron in food.

(5) Sow not "painted" at first and then painted in an attempt to cure anaemia.

(6) Sow not "painted" at first, but given separated milk with her ration. Pigs became anaemic and sow was then painted.

(7) Not "painted" but reared outside on grass after one week old.

(8) Indoors and "painted." Young pigs to receive iron sulphate in food.

(9) Not "painted" but sod put in pen daily

The iron sulphate solution was similar to that used by Hamilton in his trials and is made up by dissolving 3¼ ounces of anhydrous ferric sulphate and ¾ ounce of copper sulphate crystals in 1 pint of hot water. When the salts have dissolved, 1 pint of feeding treacle is added.

The pigs were weighed weekly and small samples (about ½ cc.) of blood were drawn from the lateral ear vein of each pig, heparin being used as the anti-coagulent. Blood haemoglobin was estimated on these samples and the values thus secured were used to trace the relative efficacy of the various treatments. Haemoglobin was estimated by means of a Bürker Haemoglobinometer (Leitz). This method is rapid and accurate.

Table I summarises the results of the various treatments.

In all cases there was an initial fall in the blood haemoglobin. Where the young pigs had access to iron, whether in the form of the iron solution smeared on the sow's teats or in the form of soil, the haemoglobin-content of the blood rose to values between 10 and 16 grammes of haemoglobin per 100 cc. of blood. Generally speakings the haemoglobin-content of the blood of the pigs which had acces,

TABLE I.

Gilt No.	Treatment.	No. of pigs. At start.	At weaning.	Haemoglobin content of blood.
A. 15	Painted with iron solution for 5 weeks and young pigs received ·1 per cent. iron sulphate in food.	7	7	Haemoglobin normal.
A. 16	Painted with iron solution for 5 weeks. No iron in food of young pigs	11	11	Did not reach quite such high figures as in A. 15.
A. 30	Not painted, but pigs to receive iron in food. N.B.—None of the pigs ate solid food.	10 (1 pig crushed in 1st week).	Nil.	Haemoglobin content fell to between $\frac{1}{3}$ and $\frac{1}{4}$ of normal value.
A. 32	Control. Not painted. No iron in food.	13	6	Haemoglobin content fell to very low levels, but rose later in those pigs which survived when they ate solid food.
A. 44	Sow not painted at first and then painted in an attempt to cure anaemia.	5	3	Haemoglobin value fell to low levels at end of 4th week. Three pigs survived but very unthrifty.
A. 42	Sow not painted, but given separated milk in her ration. Pigs became anaemic and sow then painted and pigs recovered except one.	4	3	Haemoglobin contents fell, but recovered after painting commenced.
A. 52, A. 55, A. 63	Not painted, but reared outside.	20	20	Haemoglobin normal.
A. 53	Indoors and painted. (Control for A. 52, A. 55, A. 63.)	10	9 (1 crushed).	Haemoglobin normal.
Sow. A. 32 2nd litter.	Not painted, but sod put in pen daily.	13	12 (1 weakling died).	Haemoglobin normal.

to soil tended to reach slightly higher values than that of the pigs receiving iron from the iron solution. There was, however, no apparent difference in general appearance and thriftiness. The haemoglobin in the blood of the pigs which did not receive additional iron fell to very low levels and the pigs usually died if the haemoglobin-content fell to about 4 grammes per 100 cc. of blood. The haemoglobin value for the surviving pigs from those litters which did not receive additional iron rose when solid food was taken, but retained their appearance of general unthriftiness for several weeks.

Post-mortem examinations were carried out on all the pigs which died in these trials and they all showed very similar symptoms. In every case pneumonic lesions were present in the lungs. The pleural cavity contained a considerable quantity of a straw-coloured fluid; the heart was pale and greatly enlarged, and both the liver and spleen were very pale indeed. These findings are similar to those of a very large number of pigs which have been examined from time to time and which were said to have died from "Blows."

It is obvious from the results of these trials, which are substantially in agreement with those of Hamilton that anaemia can be prevented by (*a*) rearing the pigs on clean pasture; (*b*) placing a freshly-cut sod from a field free from parasitic infection, or (*c*) by painting the sow's teats twice daily with the iron treacle solution and following this up by adding 0·1 per cent. of iron sulphate to the food of the young pigs. At Hillsborough we were not able to adopt the first method of rearing the pigs out of doors for practical reasons. The second method of placing a sod in the pen each day is laborious when dealing with a large number of sows and increases considerably the time necessary for cleaning.

The third treatment of painting the sows has been adopted as a general practice and this has given complete control of anaemia. The time necessary to carry out the treatment is negligible—a matter of a few seconds per sow each day. A sow will normally suckle her litter when she returns from being exercised and the "painting" is usually carried out at this time so as to ensure that the little pigs receive their small dose of iron. This treatment has been used with some seventy litters and in no case has there been any sign of ill-effects to the udders of the sows.

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AGRICULTURAL CHEMISTRY

SOIL ACIDITY FROM THE ADVISORY POINT OF VIEW*

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From early times the necessity for liming was recognized, and apparently in many districts our ancestors had the sense to put their beliefs into operation even to the extent, in some cases, of laying up stores which have persisted to the present day.

In the more immediate past of the nineteenth century, economic conditions in the countryside, coupled with a somewhat distorted view on the use of artificial manures, led to a curtailment of the practice of liming. The disastrous results of the practice falling into disuse, particularly in areas of the lighter sandy soils, is a matter of common knowledge, and contributory to some of the troubles of the present-day agriculturists.

It would be no wild estimate in saying that, at the opening of the post-war period, 70 to 80 per cent. of the lighter soils of the Midlands were seriously deficient in lime. What the conditions were in other districts I am not prepared to say, but probably very similar.

During the last fifteen years, as a result of the effect of more than one influence, among which we believe that agricultural education has played its part, the position has naturally changed with the result that in the more enlightened areas farmers are again paying attention to the liming question, realizing that it is fundamental to high fertility and good husbandry. The farmer is no longer in the happy position, however, of being able to apply lime *ad lib.* for the obvious reason that the cost of the operation has increased so enormously: he therefore thinks twice before he undertakes an expensive liming campaign, and he seeks advice.

The responsibility of giving advice usually falls on the shoulders of the County Organizer and the Advisory Agricultural Chemist and under ideal conditions of co-operation, they must come to a reasonably accurate decision. There are, of course, numerous independent organizations also handing out information, some of which is good and some distinctly bad.

Field Observations.—Whoever is responsible for examining the soil in the field should take pains to ascertain all the available facts

* Paper read at London P.R.C., December, 1935.

and make such preliminary tests as may be deemed necessary. In doing this, the appearance of the crop, the nature of the soil, the kinds of weeds growing, the history of cropping and manurial treatment should all be taken into account and the use of a colorimetric indicator is also common nowadays. Some observers, often aided by smell and taste of the soil, develop an instinct for spotting soil acidity, but occasions often arise when even these experienced persons fail.

Value of the pH Determination.—During the last fifteen years development of the conceptions of hydrogen-ion-concentration, commonly expressed by the *p*H figure, and also of base exchange has placed the whole subject on a much firmer footing. Many workers regard the determination of the *p*H value as the most powerful weapon ever placed in their hands. Whether that is true or not there can be no doubt that it has made the work of the adviser very much easier. Probably it would be fair to say that, like many other determinations, it proves most useful in the hands of those who realize not only its value but also its limitations. Its value lies in its expression of the intensity or degree of acidity. It says nothing about the total amount of acidity per acre of soil. This latter quantity will vary enormously for different soils having the same *p*H value. On the whole, light soils have the lowest amounts of total acid material per acre and heavy or peaty soils the most. A determination of the *p*H, either in the field or in the laboratory does not disclose the amount of lime necessary to remove the acidity. It is frequently possible to have two soils, viz., a sand and a clay with similar *p*H figures, the former requiring a ton of lime and the latter three or more tons to bring about a similar change in reaction. Similarly in comparing a sandy soil with a peaty soil the divergence in requirement is even greater, since weight for weight a peat needs approximately twelve times as much lime to produce a similar change in reaction.

It should be clear therefore that the colorimetric test in the field so frequently made nowadays by advisers cannot be regarded as being other than a rough estimate of acidity. Any attempt to give advice on the amount of lime required based on the use of a colorimetric indicator is wrong in principle, unless the operator is conversant with the particular type of soil with which he is dealing. What then is the value of the *p*H measurement in advisory work? By an examination of very numerous cases in which crop failure has been due to acidity it has been possible to determine the approximate points on the scale at which various agricultural plants fail. Naturally the figures cannot be regarded as being absolute and

will doubtless vary at various times in the same soil and also from place to place. Provided the adviser recognizes this fact he has in his hands a strong weapon which will enable him either to account for the failure of a particular crop or to say whether the conditions are favourable or otherwise for a particular crop to be grown in the future.

TABLE I.

CRITICAL *p*H VALUES FOR CROP FAILURE.

Alsike	5·6
Red Clover	5·5
Sugar Beet, Mangolds and Barley	5·3
Wheat	5·1
Swedes, Cabbage, Savoys, etc.	4·9
Kale	4·5
Ryegrass	4·3
Oats	4·2
Potatoes	3·8

Apparently the range of reaction between failure and satisfactory growth is rather narrow.

Before leaving the question of reaction it should again be emphasized that there is a natural variation of the *p*H figure in a soil for reasons not too apparent. One contributory factor would seem to be the concentration of salts in the surface either added as manure or which accumulate during a drought. In one experiment at the College the control has shown changes varying from 4·8 to 5·3 (half a *p*H degree) during the past seven years. In another experiment where the reaction is measured monthly there has been a variation of 0·8 over the year.

Exchangeable Calcium.—It has been established that the colloidal matter (clay and humus) of the soil is the seat of the reaction changes. Apparently the particles of the colloidal matter have attached to them, in a state of loose combination, acidic and basic materials. Should there be an increase in the amount of acidic material then there is a corresponding drop in the amount of basic material and the soil becomes more acid. A change in the opposite direction results in the soil becoming less acid. The material producing acidity is hydrogen and the responsibility for alkalinity falls on such bases as calcium, potassium, ammonium, magnesium and sodium. They are referred to generally as "adsorbed" or "exchangeable" ions. By far the most frequent of the basic ions present under our British conditions is calcium, and it is convenient to disregard the other elements in our examination of the problem of acidity. So we might say that when conditions result in a decrease in the exchangeable calcium (which is accompanied with an

increase in the exchangeable hydrogen) a soil becomes more acid, and with an increase in the exchangeable calcium, such as follows liming, the soil will become less acid.

The amount of the exchangeable calcium can be accurately determined and the figures obtained are used by some workers to assess the acidity status and the necessity for liming or otherwise. Although the exchangeable calcium figure is less liable to fluctuation than the *p*H, nevertheless variations are found from season to season. In the experiment referred to earlier, the control has shown fluctuations between 0·05 per cent. and 0·08 per cent.

If the exchangeable calcium contents are to be used as a guide, then the critical minimum for each crop, which will be different for each soil type, must be known.

Doubtless in a part of the country where soils tend to fall into relatively few classes, this method can be used, but in other parts, such as the Midlands, where the diversity is considerable, some time must elapse before critical criteria are forthcoming.

Degree of Unsaturation.—It can be assumed that the colloids of a soil in which excess free calcium carbonate has occurred for some time will be saturated with respect to calcium. It is not frequent, at any rate in the Midlands, to find many such soils, but the amount of lime required to produce such a degree of saturation can be determined in the laboratory. This amount is subject to fluctuation from one soil type to another, depending on the proportions of clay and organic matter present, but for any particular type of soil it may be regarded as relatively stable unless it has been treated in an abnormal fashion. If, then, the exchangeable calcium in a soil falls below that amount recognized for saturation, then it can usually be regarded as being acid to an extent depending on the degree of unsaturation. With a low degree of unsaturation a soil will be only slightly acid and with a high degree of unsaturation it will be markedly acid.

Lime Requirement.—Having dealt at some length with methods of assessing acidity, the question of the necessary amount of lime to apply arises. From what has been said with regard to the relative tolerance of crops, it should be obvious that different quantities of lime are necessary in order to restore the conditions suitable for the growth of different plants. As an example, on a soil with a *p*H of 4·0 a light dressing would restore satisfactory conditions for oats, whereas a considerable dressing would be necessary for red clover. Other considerations have, however, to be taken into account, and one of these is the British farmer who usually arranges his cropping in a rotation and has to budget, therefore, for the most

sensitive crop in that rotation. The necessity for an estimation of the amount of lime to produce satisfactory conditions for the least tolerant crop consequently arises. It should be said here that the number of methods which have been suggested are legion.

The logical and obvious method would be to attempt to discover just that amount of lime which would be required to bring the soil to a point of safety above the critical acidity value of the most sensitive crop to be grown. This is reasonably simple in the laboratory but a certain amount of difficulty arises in transferring that figure to field conditions. Our own experiments lead us to believe that about two-and-a-half to three times the amount indicated in the laboratory is required to produce a corresponding effect in the field. This figure agrees with those of Jensen and other workers.

Everyone engaged on soil advisory work is familiar with the term "lime requirement." The method employed in this country is usually that of Hutchinson and McLennan and consists in treating a soil with a solution of calcium bicarbonate under standardized conditions. It is essentially a method of estimating the extent of unsaturation in terms of the amount of lime necessary to adjust the soil approximately to neutrality. With one particular type of soil variations in the lime requirement figure will roughly indicate variation in the degree of acidity, but such will not be the case when comparing soils of distinctly differing types. Variations in either or both the clay and humus content, as well as in acidity, will effect corresponding changes in the lime requirement figure and it can no longer be used as a safe guide in estimating acidity. As an example, the lime requirement on a red sandy soil of the Bridgnorth Series at pH 6 was 15 cwts. of $CaCO_3$ per acre, while the corresponding figure of a peaty soil proved to be 12 tons of $CaCO_3$ per acre. It is interesting to note that in neither case was lime necessary for crop growth, and consequently care must be taken in interpretation of such results.

Free Carbonate of Lime.—From the foregoing it should now be clear that the proportion of exchangeable lime in a soil is directly responsible for control of acidity. What then is the part played by the free lime? When present in excess it serves to keep up the stock of exchangeable lime and doubtless largely supplies that part which is removed in drainage. It will continue to function thus until by solution it is entirely removed. The period of persistence of free lime in the soil will bear some relation to the total quantity applied. In the case of the liming experiment (in Field Y) referred to, free carbonate persisted on the plots dressed with the maximum quantity (100 cwt. per acre) for a period of six years, whereas on

those plots receiving 50 and 25 cwts. it had disappeared after periods of five and four years respectively. The rapid disappearance of free carbonate on all plots in the first four years was accompanied by a steady rise in the exchangeable lime depending on the amount of the original dressing. As soon as the reserves of free lime were exhausted, a diminution in the exchangeable lime occurred, accompanied by a corresponding increase in acidity. At no time in the experiment has the soil reaction exceeded neutrality, the nearest approach being 6·9 on the plots receiving the maximum dressing. It has been found that the annual rate of loss of lime from the soil over a period of seven years is closely related to quantity originally applied.

A calculation based on the existing quantities of exchangeable lime still present in the soil, using that of the control plot as the normal minimum, shows that the rate of loss of lime as carbonate over a seven-year period is least at a low rate of application and a maximum at a high rate of application. Stated otherwise the losses are proportional to the amounts applied. In the case cited they are approximately:—

1 cwt.	per annum	on the	25 cwt.	per	acre	dressing.
3 cwts.	,,	,,	50 ,,	,,	,,	,,
6 ,,	,,	,,	100 ,,	,,	,,	,,

The lime requirement of the soil at the commencement of the experiment was 40 cwts. of carbonate of lime per acre, and assuming lime is applied to sour light soils at about that rate, then the usually accepted figure of 4 to 5 cwts. of carbonate would appear to be somewhat high for a soil naturally non-calcareous. (The calculation is based on an acre weight of 1,700 tons for the top eleven inches, which is the maximum depth to which the soil has been twice ploughed). Whatever weight of soil per acre is assumed the generalization mentioned above holds good.

Duration of Liming.—Not only the question of the quantity of lime to apply but also the practical problem of the duration of effect is one which has to be taken into account in giving advice to the farmer. Some agriculturists, having once corrected the initial acidity, prefer to add a small amount (10 cwts. CaO) every four years to repair the wastage. Unfortunately they are not in the majority. From the experiment to which reference has been made it has now been found that the 25 cwt. dressing ceased to be efficient for crop growth purposes after 4 years, the 50 cwt. after about 6 years. The 100 cwt. plots would appear to need further treatment after ten years. As a generalization it may be stated that lime applied at the rate of the lime requirement figure will be effective for

5 or 6 years. Naturally such a statement is made with considerable reserve since the kind of manure, etc., used during that interval will have considerable influence on the rate of lime wastage.

Crop Growth in Relation to Acidity.—Were it not for the fact that crops are to be grown the measurement of soil acidity would only be of academic interest.

The study of crops on plots under conditions of graded acidity shows that there is a very rapid response in growth with decreasing acidity when the critical point has been passed. This appears to hold good for all sensitive crops yet grown in our experiments. Slight changes in soil acidity near the critical point such as would be expected in nature result in patchiness. A somewhat greater shift in reaction would result in either complete failure or entirely satisfactory growth. In the cultivation of the sugar beet crop many instances have been found where a general *p*H of 5·0 has meant almost complete failure (2 to 3 tons per acre). On the other hand at *p*H 5·6 crops yielding 12 tons per acre are often successfully grown. It should not be inferred from this that it would be wise to pass a composite soil sample having a *p*H of 5·6; for safety's sake it would be advisable to place the safety mark somewhat higher.

The problem has, however, a deeper interest than that of gross yield only. The composition of the produce is of vital importance to the stock feeder and this is true not only of arable crops but of grassland. Unfortunately time will not permit of any adequate treatment of this subject, which in its importance merits attention in a separate discussion.

Geographical Distribution of Acidity.—At the present time soil surveys are being conducted in a few parts of this country, but unfortunately the gaps in the service are only too frequent and apparent. It is, however, to the available maps of areas of our country that we must turn for precise information on the geographical distribution of soils. The study of a regional map, or one of a more detailed nature, such as the standard 6-inch scale map, will reveal a number of classes of soil referred to as series. The series is the unit in which we should seek information on this question of acidity. The map of Shropshire soils will show several series which may be regarded as inherently acid and others where the lime status is such that lime treatment is seldom of importance. Examples of series which have a natural low base status are the Bridgnorth, Newport, Clive, Baschurch and Shifnal and in these acidity may be expected as a factor limiting growth. In other series, such as the Salop, Worcester and Cegin, lime shortage seldom occurs.

DEVELOPMENTS IN THE CHEMISTRY OF FUNGICIDES USED ON FARM CROPS*

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The fungicides widely used in agriculture may be divided into two groups:—Foliage protectants and seed disinfectants. Economic factors limit the employment of the former group to crops of high market-value yield per acre. Of the main agricultural crops only potato and celery will bear the high cost of spraying and, in this country, the prevalence of diseases and pests of these crops is fortunately such that the need for spraying or dusting is confined to the control of the fungi causing "blight." For this purpose, a foliage protectant is required and the oldest and still the most widely-used of such protective fungicides is Bordeaux mixture.

Bordeaux Mixture.

As Bordeaux mixture is troublesome to prepare and to apply, many attempts have been made to find a more convenient substitute. It is remarkable that of the many substitutes proposed and tested only one, Burgundy mixture, has proved a successful competitor. But the preparation of Burgundy mixture is no simpler than that of Bordeaux mixture and this substitute has survived for use on potatoes only in localities where a satisfactory supply of lime, one of the components of Bordeaux mixture, is not available.

The failure of Bordeaux substitutes indicates that there are certain physical and chemical properties which contribute to the efficiency of Bordeaux mixture, but which are absent or less prominent in the case of the substitute. It is evident that the royal road to a successful substitute lies through the elucidation of those properties which contribute to the success of Bordeaux mixture. Progress has been made along this road in recent years and this progress is best described after a preliminary examination of the mode of action of Bordeaux mixture.

Being protective in nature, it is generally agreed that Bordeaux mixture functions through the slow formation, from the deposit left after spraying, of a substance which prevents infection of the host plant by the fungus. Two sets of factors are thus involved: firstly, the chemical factors of the nature of the protective deposit and the manner of formation of the active fungicide; secondly, the

* Paper read to Chemistry Committee, July, 1935.

physical factors influencing the persistence of the deposit upon the foliage to be protected from fungal attack.

What then is the chemical character of the deposit left by Bordeaux mixture? The interaction of copper sulphate and calcium hydroxide, according to early views, resulted in the formation of one or a mixture of a series of basic sulphates and calcium cuprites. More recent phase rule studies indicate, however, only three definite basic copper sulphates of which only the trioxysulphate, $4CuO.SO_3.3H_2O$, is stable at temperatures usual in the preparation of Bordeaux mixture. Further, stoichiometric studies show that the first product of this interaction at ordinary temperatures is this basic salt. As Bordeaux mixture contains an amount of lime greatly in excess of that required for the complete precipitation of the copper present as this sulphate, the Bordeaux precipitate is the product of the further interaction of this salt with calcium hydroxide. Electrometric evidence shows that this interaction involves equimolecular amounts of copper sulphate and lime and indicates that the final product of interaction is cupric hydroxide.

If cupric chloride be substituted for copper sulphate in this interaction, the precipitate of cupric hydroxide is slowly converted to the nigger-brown cupric oxide. There is no obvious tendency of this dehydration to the oxide to occur in Bordeaux mixture. A satisfactory explanation for this difference is found in the probability that the cupric hydroxide of Bordeaux mixture is stabilized by adsorbed calcium sulphate. If this adsorbed sulphate is removed by washing, the Bordeaux precipitate will blacken. Yet when applied to foliage, the cupric hydroxide-calcium sulphate complex of Bordeaux mixture shows no tendency to blacken and it is probable that some change in its character occurs after spraying. The evidence at present available indicates that carbon dioxide is involved in this change and it seems reasonable to suppose that dehydration is prevented by the conversion of the complex to a basic carbonate.

On exposure the excess calcium hydroxide will be converted to the carbonate, and these two changes which occur *in situ* after the application of Bordeaux mixture to foliage serve to account for the excellent adhesiveness of the Bordeaux deposit to foliage. The failure of many Bordeaux substitutes may then be due to lack of retentivity associated with the inertness of the substitute to reactants, such as carbon dioxide, which come into play after application to the foliage.

The range of possible substitutes will be enlarged if means other than *in situ* changes be found to improve the adhesiveness of the substitute to foliage. Progress has recently been made in the

discovery of spray supplements which improve the retentivity of spray deposits and which are termed "stickers" in American spray practice. These products include adhesives, and, of greater interest, oils. The incorporation of cottonseed oil of low free fatty acid content in Bordeaux mixture has been found to improve the retention of copper upon the potato foliage to an extent such that the reduction of the copper sulphate and lime content to half that of ordinary Bordeaux mixture did not reduce the fungicidal efficiency of the oil-Bordeaux spray. It is fortunate that Bordeaux mixture functions so well as an oil-in-water emulsifier that the oil-Bordeaux emulsion obtained by merely stirring the components is stable enough for use as a spray. With high-boiling petroleum oils which have to be highly-refined in order to be safe for application to foliage, the emulsion so produced is not sufficiently stable and it is better to use a manufactured emulsion. Recent work at Long Ashton has indicated that the petroleum oil-sulphite lye emulsion is suitable for use as a sticker with copper-containing sprays.

COPPER PASTES.

Returning to the consideration of the chemical factors which contribute to the efficiency of Bordeaux mixture, a commonly-held view is that the active fungicide is soluble cupric copper formed either by atmospheric or biological agencies from the Bordeaux deposit. Our requirement therefore becomes a copper derivative from which soluble copper is slowly liberated on exposure upon the leaf surface. One interesting line of work arose from the spray retention work described above. It was observed that, in the presence of sulphite lye, the Bordeaux precipitate will, under certain conditions, undergo reduction to cuprous oxide. As spray trials indicated that partial conversion to cuprous oxide was accompanied by no apparent loss of fungicidal efficiency, if seemed probable the cuprous oxide is itself fungicidal. The results of trials so far made show that cuprous oxide, in the presence of a suitable sticker is an excellent Bordeaux substitute. Equally good results have been obtained with cuprous cyanide which is of special interest to the applied biologist as it has been stated to possess insecticidal properties.

Copper compounds found of promise in America include cuprous oxide, which has been proved useful for the control of "damping-off" of seedlings, cupric phosphate and ammonium cupric silicate, introduced under the trade name of "Coposil." At Long Ashton, the examination of the fungicidal properties of various copper derivatives has been continued in the laboratory and the extent to

which this property is shown is surprising; even cupric oxide has proved effective. It is, however, evident from theory and practical results that an important factor determining fungicidal efficiency is the ease of formation of soluble copper from the insoluble protectant. On the analogy of the insoluble phosphatic fertilizers, it is convenient to apply the term "availability" to these factors. The precise mechanism of the formation of soluble copper is still unknown, but there are clear-cut differences in the fungicidal efficiency of various copper derivatives which are explainable by this availability concept. Thus cupric ferrocyanide appears to be almost devoid of fungicidal properties as might be expected from its inertness and insolubility. Similarly, the phthalocyanine, though soluble, is inactive fungicidally a result no doubt of its great chemical stability.

At the other extreme, too high an availability will result in a too rapid loss of fungicidal properties on exposure, and possibly, too drastic an action on the host plant.

Upon these lines, namely, the discovery of the copper derivative of the most favourable availability and the enhancement of retentivity by the use of a suitable spray supplement, the deduction of the required Bordeaux substitute should not be long delayed.

Copper Dusts.

An alternative to the use of Bordeaux mixture is the employment of copper dusts, by which means the difficulties of application are lessened. Copper dusts are now extensively used in this country for the prevention of potato blight, but in America, it is the unanimous opinion of critical test and general experience that they are not as effective as Bordeaux mixture. Indeed there is now a strong tendency for advisory officers in the States to abandon the recommendation of copper dusts except as supplements to routine sprays. It is for this reason that we, at Long Ashton, have preferred to explore the possibilities of improved copper sprays rather than to begin fundamental work upon the copper dusts. The following discussion of the copper dusts is therefore confined to general observations of such proprietary dusts as have been submitted for examination.

These products are conveniently classified into three groups: firstly, the basic salts. The idea of these products is to use the basic sulphates which were, at one time, considered to constitute Bordeaux mixture. They appear to be made either by the direct precipitation of copper sulphate with alkali or, according to the patent literature, by the digestion of scrap copper in copper sulphate solutions under various conditions such as the passage of air. The basic chlorides

and the basic carbonate also appear in certain of the proprietary products. They are distinguished from other types of copper dust by their high copper content and neutral reaction. In spite of their high copper content, dusts of this type have never been widely adopted and it is possible that their comparative failure is associated with poor adhesiveness and liability to cause foliage damage.

These disadvantages are countered in the second group, the basic salt-lime mixtures, by the addition of hydrated lime. The presence of free lime will presumably reduce availability and, by *in situ* carbonation, function as a sticker. American work has shown that for hydrated lime to act as a good sticker, the foliage should be moist. Hence better results are obtained in such dusts are applied at early morning or at night when dew is on the foliage. On storage, especially under damp conditions, this type of dust tends to undergo dehydration with the formation of the black oxide. Dusts of the basic salt-lime type may then be recognized by their alkalinity and frequently by their dark colour.

In the third type of dust, the copper-lime dust, the idea is to obtain a mixture which will, in the presence of moisture upon the foliage, react to form the Bordeaux precipitate. Such products consist of a mixture of hydrated lime and monohydrated copper sulphate. They are distinguished by their alkalinity and by the colour change which accompanies their interaction with water. In proprietary copper-lime dusts it is not unusual to find other materials such as sulphur, and one well-known British product has a composition corresponding to 20 parts by weight $CuSO_4.H_2O$, 75 parts hydrated lime and 5 parts sulphur.

An important advance has been the standardization of certain types of copper dust, and products are now available which conform to the specifications recently published in Bulletin 82 of the Ministry of Agriculture and Fisheries. The advisory officer who feels justified in recommending copper dusts as substitutes for Bordeaux or Burgundy mixtures would therefore be wise to restrict his recommendation to dusts conforming to these specifications.

Organo-mercury Seed Disinfectants.

Turning now to another metallic fungicide, mercury, a totally different story is to be told. The first successful use of a mercury derivative for the control of seed-borne cereal diseases was by Hiltner, who at the beginning of the century, used mercuric chloride against the *Fusarium* disease of rye. As this fungus is carried over as a dormant mycelium in the seed, Hiltner's discovery was of profound importance. It showed the feasibility of employing a

protective fungicide for seed treatment in contradistinction to the direct fungicides, e.g. formaldehyde and copper sulphate, which are used against fungi such as bunt of wheat which are carried over on the exterior of the seed.

It was not long before the organo-mercury derivatives developed for chemotherapeutic purposes were substituted for mercuric chloride, an application credited to Wesenburg of the I.G. Farbenindustrie A.G. Indeed the development of the organo-mercury seed disinfectants has been due almost entirely to the activities of one or two commercial firms, notably the German I.G., interested in the manufacture of therapeutic chemicals. As a result it is difficult to trace in any complete manner the evolution of these products from a fundamental aspect. From the patent literature and from disclosures generously made by the manufacturers the following particulars have been obtained.

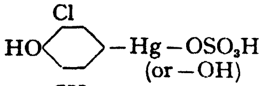
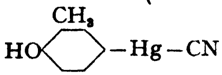
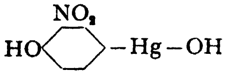
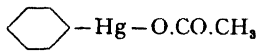
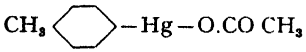
The organo-mercury compounds which have so far been used as the active constituents of seed disinfectants all appear to be of the structure represented by R–Hg–X, R being an organic radicle to one carbon atom of which the mercury atom is directly bound, and X being a salt-forming group satisfying the second mercury valency. In the first mercury seed disinfectant to be widely used, Uspulun, introduced in 1915, a chlorphenol formed the organic part of the molecule, the salt-forming group being either the hydroxyl or the sulphate radicle. To bring this compound into solution, alkali was necessary and Uspulun therefore contained alkali together with a colouring matter added to conform to poison regulations. Germisan was stated to be a similar cresol derivative, cyanomercury cresolate. The presence of the cyano group is of interest as it has been stated that the substitution of cyanide, iodide or ferrocyanide to satisfy the second mercury valency increases the efficiency of the mercurated cresol.

These two products were intended for use in seed steeps and, in 1924, the first mercury dust treatment, following the success of basic copper carbonate, was introduced in the form of Tillantin-R (Dry Uspulun) of which the active constituent was stated to be an *ortho*-nitrophenol mercury derivative.

At about this time the fundamental work of Gassner was published. Gassner examined the fungicidal and seed-injuring properties of organo-mercury compounds, determining amongst other criteria, the *dosis curativa* or concentration necessary to kill the smut spore by immersion methods. Certain of his figures are quoted in Table I in order to illustrate the high potency of methyl mercury iodide. This enhanced toxicity may be associated with the fact that this

derivative contains a hydrocarbon group instead of the phenolic radicles of the earlier seed disinfectants. Further, it will be noted that high potency is shown towards smut spores, organisms to which the phenolic mercury compounds were not markedly toxic.

TABLE I.

Name of Product.	Active Constituent. Structure.	*Dosis curativa.* (Gassner).	Content of metallic mercury, per cent.
Uspulun		0·08	16·8
Germisan		0·12	16·1
Tillantin-R.		0·07	3·4
Methyl mercury iodide	CH_3-Hg-I	0·001	—
Ceresan (Europe) ..		—	1·5
Agrosan G.		—	1·5
Ceresan (America) .. } Granosan (Europe) .. }	$C_2H_5-Hg-Cl$	—	2·0*
Ceresan, new improved (America)	$C_2H_5-Hg-H_2PO_4$	—	1·3
Ceresan U. 564 ..	—	—	2·5
Ceresan U.T. 1875a ..	—	—	1·5

The structure here indicated is the simplest which conforms to the manufacturer's description of the product.

It is therefore not surprising that subsequent seed disinfectants contained mercury derivatives of the simple hydrocarbons as, for example, Agrosan G and the European brand of Ceresan which are said to contain the tolyl and phenyl mercury acetates respectively as the active ingredient. Ceresan of American origin, identical with Granosan introduced into this country, is said to contain ethyl mercury chloride, whilst the new improved Ceresan of America contains the corresponding phosphate.

The phenyl mercury acetate dusts are not readily applicable to steepage methods of seed treatment, for which purpose a new type of Ceresan (U. 564) has recently been introduced, together with a corresponding product (U.T. 1875a) for use as a dust.

* It is not clear, from the manufacturer's statement, whether American Ceresan contains 2 per cent. mercury or 2 per cent. ethyl mercury chloride.

The gradual evolution of compounds of increasing fungicidal potency is shown by the comparison of the actual mercury contents of the various products. Whereas the earlier Uspulun and Germisan contained over 18 per cent. mercury, the recent Ceresan contains but 2·5 per cent. A similar reduction of mercury content is shown between Tillantin R and the later dusts. Finally, recent products are effective against a wider range of seed-borne diseases than the earlier organo-mercury seed disinfectants.

Subsequent to the reading of this paper, an important paper by Dillon Weston and Booer, has been published in the *Journal of Agricultural Science*, to which the attention of readers interested in the fundamental aspects of the mercury seed disinfectants is directed.

THE FISHY FLAVOUR OF MILK CAUSED BY FEEDING BEET BY-PRODUCTS*

By W. L. Davies

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The study of the causes of a fishy taint in foods has opened up a new field of investigation in fat deterioration. Curiously, no serious attempt has been made to explain the fishy flavour of fish products; it has only been the subject of study when the flavour takes on the aspect of a taint, such as in butter, dried milk, milk, bacon and cottonseed oil. The fishy flavour of butter is the first step in the oxidative breakdown of the fatty constituents under the influence of acidity and contamination with traces of iron and copper. The lecithin of the butter undergoes hydrolytic oxidation, the choline residue breaking down to trimethylamine oxide; this compound reacts with the unsaturated acids of butterfat to yield the fishy flavour. A similar explanation holds for fish products, except that the trimethylamine oxide is already present in fish muscle and can react with fish fat as soon as autolysis commences.

The physical state of the fat in milk causes it to be specially susceptible to autoxidative deterioration and, in the rapidity of the development of fat off-flavours (oiliness, etc.), the fishy stage is never detected. But, if conditions exist in the milk whereby a carrier of active oxygen in the form of trimethylamine oxide is present in appreciable amount, a fishy flavour in milk may at times be detected. The occurrence of this condition explains the sporadic

* Paper read to the Dairy Committee, July, 1935.

occurrence of a fishy flavour in milk from cows fed on beet by-products. A short description of the mechanism of the development of the fishy taint, therefore, follows.

It has long been recognized that trimethylamine is closely associated with fishy flavour and the base has been isolated in small quantities from tainted material. This, however, is not sufficient evidence on many grounds that trimethylamine itself is the cause of fishiness. Pure trimethylamine is more ammoniacal than fishy in smell, and it is quite possible that the odour and taste are developed when the base reacts on the sensory mucous membranes. It is more probable that it is the reactions of its derivative, trimethylamine oxide, which are responsible for fishy flavour, especially in cases where the taint is preformed in the food. On physico-chemical grounds, trimethylamine is a strong base in aqueous solution; solutions of its salts will be strongly ionised. The tendency to its formation biologically is precluded on osmotic grounds unless it plays the part of a functional base. It was necessary, therefore, to look for causes of fishiness other than the strong base, trimethylamine.

Beet By-products.—The beet by-products used as food for the dairy cow consist of beet tops, molassed beet pulp, and, less frequently, beet molasses. These three foods contain in common, a tertiary nitrogenous base, betaine, which is present only in very small traces in the normal diet of the cow. It may be regarded as the precursor of the compound responsible for the taint. Beet molasses contain 5·4 per cent., the molassed pulp, 1·8 per cent. and beet tops, about 1·5 per cent. (in the dry matter) of betaine. The processed products (molasses and pulp) contain traces of trimethylamine, the oxide, and, possibly a trace of an isomer of betaine, methyl dimethylaminoacetate. Choline may also be present in traces.

Metabolism of Tertiary Nitrogenous Bases in the Cow.—The first step naturally has consisted in examining the metabolism of the above group of nitrogenous compounds in the dairy cow. This has been carried out for the five bases by feeding definite quantities and examining the output of tertiary nitrogenous base in the urine over a period of time up to 24 hours. Only a trace of trimethylamine appears in the urine but trimethylamine itself when fed, is excreted completely as the oxide; the oxide is also quickly eliminated unchanged when fed. But, with betaine, choline and the ester, only from 20 to 35 per cent. of the nitrogen is excreted in the urine as trimethylamine oxide. The significance of this form of metabolism is that all tertiary nitrogenous bases yield a common simple metabolite of a tertiary nitrogenous nature; and, therefore, the

possible breakdown of the betaine of the food to other bases during the process of manufacture is probably of relatively little importance.

In studying the rate of excretion of the metabolite, it was observed that a peak of excretion was shown at a time after feeding which depended on the amount of nitrogenous base fed; the concentration of the metabolite in the urine at its peak of excretion also increased with the amount initially fed. The significance of this was that for the period immediately preceding the peak there must have been a considerable concentration of the metabolite in the blood, at which time it was also possible for the metabolite to be at its maximum concentration in the "residual nitrogen" fraction of any milk present in the udder at that time.

Reactions in the Milk Produced.—Our knowledge of milk composition has advanced greatly during the past few years, particularly with regard to the variation in the amounts of the minor constituents which are transferred from blood to milk in an unchanged state. The amount of non-protein nitrogen for instance, is an individual characteristic of the cow and affords a useful index of milk quality; a high non-protein nitrogen indicates low quality milk, or a breakdown in the selectivity of the secretory tissue so that the milk is unduly diluted with blood serum-constituents. There is, at any rate, the possibility of considerable variation, from cow to cow, of the amount of trimethylamine oxide which can enter the milk from the blood during the period of secretion. This amount will naturally depend on the concentration of trimethylamine oxide in the blood at any particular time; the lowering of its concentration in the blood will also cause infiltration of some of the base back from the milk. The time-interval between feeding and milking is therefore of prime importance, since, if a sufficient time elapses between feeding and milking for the metabolite to be eliminated from the cow's system via the urine, the possibility of occurrence of taint is considerably lessened. The time taken to reach the peak of excretion, again, varies with the initial quantity of betaine fed, so that the question of quantity of betaine-containing food has to be considered.

The small quantity of trimethylamine oxide which enters the milk during secretion reacts with the fat, and it is the association of the oxide with the unsaturated acids of the fat which gives the fishy flavour. Up to the present it has only been proved that the above association occurs. The taint is concentrated in cream and is imparted to the butter. The association of tertiary nitrogen with unsaturated acids in fish-liver and other fish oils has been definitely established. Further detailed work is necessary (*a*) to

find out whether it is the most unsaturated acids, e.g., linolenic and higher acids, which are known to be present in milk fat, which are responsible for the fixation of the active oxygen and (*b*) to examine the effect of the seasonal variations in the amount of the natural inhibitors to fat-oxidation in milk, on the development of the taint; this last-named factor is associated with the other food in the ration and possibly with the changes due to heat treatment in the molassed pulp fed. The multiplicity of factors concerned with fishy taint development is undoubtedly associated with the sporadic appearance of the taint under practical conditions.

Advisory Work in Connection with the Taint.—The above findings point to various precautions which have to be observed in the feeding of betaine-containing foods. The quantity of betaine fed and the time-interval between feeding and milking are the most important. Molassed beet pulp may be looked upon as having the same feeding value, pound for pound, as oats or other cereals and, although the price per ton is low, the material should be judiciously fed. Agreement has been reached that the tentative amount of 9 lb. per head per day, divided into two equal quantities of 4½ lb. of molassed pulp should not be exceeded; these quantities should also be fed in the soaked condition at the time of milking, i.e., as far away from the next milking as possible. The betaine-equivalent of this quantity as beet tops is roughly 60 lb., the feeding of which, of course, cannot be managed so effectively as with the more concentrated pulp. The amount of tops consumed by different cows also varies considerably but feeding with tops *ad lib.* should be avoided, as also the feeding of tops and molassed pulp on the same day if the betaine-equivalent is thereby raised above the safety limit.

Co-operative experiments have indicated that taint development is more prone to occur with badly-browned or blackened pulps. This requires further investigation, and it is possible that the effect may lie in the different quantities of fat protectors transferred to the milk by the various classes of pulps, a matter which could be rectified by supplying the deficiency in browned pulp by feeding some form of green material.

Another subsidiary problem is the possible transference of the properties of fishy milk fat to the fat of bacon pigs fed on such milk in a similar way to the transference of the properties of the oil of fish meals under the same conditions.

DAIRYING

RATIONING AND MILK COSTS*

By S. R. Wragg and H. T. Watkins
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The object of this paper was in the first place to investigate the possibilities of closer co-operation between the Agricultural Economist on the one hand and the Agricultural Chemist on the other. It was thought that with a closer co-ordination of the work carried out by members of these two branches of agricultural research, the value of the results obtained might be considerably extended.

As a suitable subject upon which enquiry in this manner might be made, we chose to study the relationship between "Rationing and Milk Costs" and for our material we examined with considerable amount of detail, statistics and other relevant data compiled by the Economics Department of the Agricultural Advisory Section of this University, during its investigation into herd management and milk costings, which has now been in progress for a number of years.

The importance of the subject was fully revealed when it was discovered that of the total costs incurred in the production of a gallon of milk, between 55 per cent. and 75 per cent. is accounted for by the feeding stuffs. The enquiry was at this stage divided into a study of winter milk production and a study of summer milk production, the former being dealt with first.

The cost of milk production in winter appeared to be strongly influenced by three factors, namely,† the method of providing maintenance, the potentialities of autumn grazing, and thirdly, economical methods of rationing.

Considering first the question of maintenance, it was found that in cases where the farmer had fed a ration of hay, straw or roots up to the full necessary requirements, the total food costs per gallon were above average costs. In fact this applied to nearly all farms who had fed 50 per cent. or more of total maintenance requirements in the form of hay, straw and roots. Proceeding from this discovery,

* Summary of paper read at P.R.C., Bristol, 1935.

† It should be understood that the order as given does not indicate any order of importance.

a strong relationship was found to exist between the food costs per gallon and joint influence of milk yields and hay production costs. A table was constructed, illustrating that with increasing hay production costs, higher yielding beasts were necessary if milk was to be produced at a profitable level. Crop costings carried out by this University over a period of several years show an average cost for good meadow hay of £3 2s. per ton, which, according to the table constructed would require an average herd yield for seven winter months of 325 to 350 gallons per cow to make possible a profitable level of production costs.

This result at a later stage led on to the importance of winter grazing, for while low yields and high hay production costs appeared to indicate an uneconomic level of total food costs per gallon, low total food costs were not as a general rule inconsistent with low yields. It was discovered on many farms that during a considerable part of the winter period, grazing can and actually does supply a considerable proportion of maintenance requirements and it is under these conditions, where this early grass is available and where the farmer has realized its existence and potential value, that low yielding herds can be managed during the winter, consistent with a profit margin. The farms producing winter milk at high costs appear to be those which have fed home-grown foods up to and even above the maintenance requirements; those farms producing milk with low food costs are almost invariably instances where between 40 per cent. and 45 per cent. of the maintenance requirements has been obtained from either winter grazing or in some few cases from concentrates.

These remarks do not apply solely to the feeding of hay, as maintenance from kale, sugar beet tops, roots, cabbage, silage, etc. (production costs assessed on the farm values as given in the Journal of the Ministry of Agriculture and Fisheries, which appear to be below actual production costs in this Province) is from 200 to 400 per cent. higher per gallon than on those farms where hay alone was the only home-grown fodder fed.

The third decisive factor in determining food costs was the ability of the farmer to ration strictly in accordance with requirements. High food costs (i.e., above 9d. per gallon) were not due merely to feeding expensive rations or unbalanced rations. The mistake was in every case bad rationing, the total quantity of starch- and protein-equivalent fed being invariably in excess of total requirements. This excess feeding was strongly in evidence not only in the production ration, but also in the maintenance ration, the starch equivalent excess in the former averaging as high as

30 per cent. of actual requirements and the excess of protein equivalent being at a still higher average of 39 per cent. of requirements. The excess fed in the maintenance ration was not quite as regular but on an average starch equivalent was fed to an excess of 10 per cent. of requirements. The protein equivalent in the maintenance was fed grossly in excess, the average being about 50 per cent.

Considering the total food requirements and the total foods fed, there was in every case a very high percentage of food value wasted, such as would in many cases have maintained in production an increase of 50 per cent. of the initial herd.

Low food costs appeared to be consistent with very correct and precise rationing, not only of concentrates but of all other foods available. On farms with low food costs (i.e. below 5¾d. per gallon) home-grown foods averaged less than 32 per cent. of total maintenance requirements. Forty per cent. of these farms fed an excess of concentrates above production requirements, which served to make up a varying proportion of the deficit in the maintenance ration. On the remaining 60 per cent. of the farms the actual foods fed as maintenance and for production were well below theoretical requirements in both cases.

The significance of this discovery lies in the fact that this deficiency of food between theoretical requirements on the one hand, and food actually fed on the other, could have been supplied by no other agency than the grazing grass during the early winter months from the beginning of October onwards.

The potential feeding value of winter grass can upon this evidence be no vague possibility, but a definite and decisive factor which, as an important determinant of winter milk production costs, calls for much greater appreciation.

Summer milk production being so intimately bound up with the question of grazing, it was found imperative to have some method of measuring the success with which farmers had grazed their land. It was moreover necessary to have an approximate assessment of the potential feeding value of the pastures and aftermath grazed by cows on each farm under consideration, during the season. Being acquainted with the type of each pasture, they were divided into four categories as follows:—

(1) Average meadow land.
(2) Poor low land.
(3) Good hill pasture.
(4) Poor hill pasture.

Upon this classification, figures were eventually deduced which gave a very fair indication of the yield of each particular farm pasture and aftermath as measured in pounds of dry matter, starch equivalent and protein equivalent. For much of this information we are indebted to the experimental work done on pasture yields in this Province, and to the published works of the Welsh Plant Breeding Station at Aberystwyth. The absolute minimum values were taken so that there would be a tendency to under-estimate rather than over-estimate the final conclusions to be drawn.

Complete stocking records on the pastures of the farms under examination were available, and so all grazing stock other than cows were eliminated by allowing them a very liberal share of the grazing. The remaining nutrients supplied by the grass were then assumed to be available for the milking cows. By calculating theoretical requirements according to maintenance and yield it was then possible to judge with what efficiency the cows had utilized their apportioned grassland. This degree of efficiency is closely correlated to the cost of summer milk production.

On farms having summer food costs (over 5·6d. per gallon) as calculated by the Economist, the grazing efficiency was astoundingly low. The available starch equivalent and protein equivalent for which there was no apparent production was as much as 80 per cent. and 65 per cent. respectively of the total available supply of each.

Turning to the low food cost farms with an average cost of 3½d. per gallon, the loss of food values in grazing was almost negligible, showing that the feeding value of the pasture throughout the summer months had been very carefully assessed and stocked accordingly. In the former case of high food costs, the cause suggested by the figures was understocking, and a consequent wastage of food values.

To summarize in a few words, economic milk production both in winter and summer is largely dependent on the farmer making the very best use of his available grassland. This has special application to the summer months, while high costs in winter are strongly related to the extensive use of home-grown foods and over-feeding both of home-grown foods and concentrated mixtures.

THE HORMONAL CONTROL OF LACTATION*

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The past decade has seen an extension of our knowledge of the physiology of sex so great as to encourage the hope that in the near future man will be able to preordain the sex of his own offspring and that of his domestic animals. Though at present this is nothing more than a goal towards which further efforts must be directed, nevertheless much of practical benefit to mankind has already resulted from recent discoveries in this field. Outstanding examples of such achievement are the invention of a test for pregnancy in the human which enables the condition to be early diagnosed with considerable certainty, and the development of successful techniques for artificial insemination of farm animals which, if intelligently applied, may well bring about a revolution in farming.

That section of reproductive physiology concerned with lactation —a subject of supreme importance to the dairy farmer—has shared in these advances to such an extent that it is now possible by suitable experimental treatment to bring into full lactation not only castrated (ovariectomized) virgin female laboratory animals but *males* also. That such laboratory experiments are but the prelude to further discoveries which may well affect profoundly the future of dairy farming is evident from the fact that already unmated virgin heifers have been caused to produce appreciable quantities of milk merely by giving them injections of anterior pituitary extract.[1]

In this article an outline will be given of the present state of knowledge regarding the factors which govern the development of the mammary gland and the initiation and maintenance of milk secretion. Since in a brief space no attempt can be made to deal with differences between various animal species in their reactions to experimental treatment, only the general conclusions which appear to emerge from the mass of experimental work carried out on a number of species will be considered. It is only possible to refer to very few of the numerous published papers dealing with this subject. These papers will, however, supply those who wish to pursue the matter further with a key to more extensive reading.

The Development of the Mammary Gland.—The mammary glands form part of the female accessory sex apparatus. They are rudimentary in the immature female and remain so until puberty, when

* Paper read to Chemistry Committee, December, 1935.

they undergo a striking increase in size. In the male they remain rudimentary throughout life except in abnormal cases which are described from time to time in the medical literature and in male laboratory animals experimentally treated as described later.

The gland of the post-pubertal female contains a system of branching ducts, the ramifications of which may be likened to the branches and twigs of a tree. Smaller milk ducts join to form progressively larger ones which finally have their outlets at the teat.

In many species the mature female exhibits a rhythmically recurring condition known as oestrus or "heat," during the height of which, only, will the female mate with the male. The oestrus cycle is correlated with a cycle of happenings in the ovary which culminates in the rupture of a follicle containing a ripe ovum and the liberation of the latter into the abdominal cavity whence it passes into the Fallopian tubes where fertilization may take place. Ovulation, or the liberation of the egg from the ripe follicle, is followed by the formation in the ovary of a new structure called the corpus luteum or "yellow body."

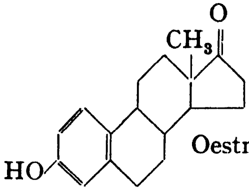
The mammary gland undergoes a periodic change in structure correlated with the oestrus cycle. During oestrus the duct system already referred to ramifies and extends, only to regress to some extent in the quiescent stage which succeeds oestrus. It should be noted that the oestrus development of the mammary gland is confined to development of the ducts, other structures which are essential for milk secretion and which will be mentioned later, not appearing.

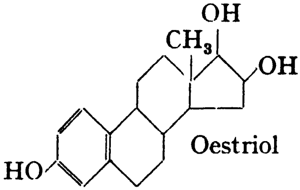
During pregnancy a striking progressive increase in the size of the mammary gland occurs. Two phases of development can be distinguished roughly as follows. During the first half of pregnancy there is considerable extension of the duct system associated with the formation of masses or lobules of secreting cells. Early pregnancy is therefore associated with a hyperplasia (or increase in tissue) of the mammary gland. In the latter half of pregnancy the increase in size is largely due to distension of the secreting cells with secretion and the growth characteristic of late pregnancy is therefore more properly described as a hypertrophy. At parturition milk secretion begins, increases in volume for some time and then gradually declines.

Recent researches, prominent among which have been those carried out in England by Hammond and by Parkes and at the Missouri Agricultural Experiment Station by Turner and his colleagues,[2] indicate that the various phases of development of the mammary gland are controlled by hormones secreted into the blood stream by the ovary and the corpus luteum, both of which

are now known to be endocrine organs, i.e., glands which produce internal secretions capable of exerting specific effects on certain bodily tissues. What is known of the effect of these and other hormones on mammary development and milk secretion will now be indicated.

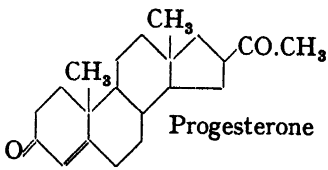
The Oestrus-producing Hormones.—The hormone which produces the phenomena associated with oestrus in the female exists in various forms, two of which are known as oestrone and oestriol (in the U.S.A. theelin and theelol). Chiefly owing to the brilliant work of Butenandt their structural formulae are now known with practical certainty.


Oestrone


Oestriol

Injection of oestrone or oestriol into castrated virgin females causes among other changes, development of the duct system of the mammary gland about equivalent to the degree characteristic of virgin females at the height of oestrus. Oestrone and oestriol do not bring about lobular development and it is not surprising that milk secretion (except on occasion in the guinea pig) is not initiated by injections of either. On the contrary there is evidence that injections of oestrus-producing hormone into lactating animals actually inhibit milk secretion.[3]

The Corpus Luteum Hormone.—Recent work has thrown much light on the puzzling question as to the function of the corpus luteum. It is now recognized as an endocrine organ which secretes a hormone called progestin or, better, progesterone. From the work of Slotta,[4] Butenandt[5] and Fernholz,[6] and their several collaborators, its structural formula appears to be well established and Butenandt as well as Fernholz have succeeded in producing it artificially from stigmasterol, a sterol found in plants.


Progesterone

Various workers have postulated a relation between the corpus luteum of pregnancy or pseudo-pregnancy (in some species) and

the mammary development which is characteristic of these conditions. Nevertheless, injections of progesterone do not usually cause development of the mammary gland of the castrated virgin female equal to that characteristic of the first half of pregnancy even when preceded by a course of oestrone injections sufficient to produce extensive duct development. However, it appears probable from the work of Turner and his colleagues that *simultaneous* injections of oestrus-producing hormone and progesterone are effective in bringing about lobular development of the mammary gland of the castrate immature female equal to that associated with early pregnancy. In most species, however, such treatment does not initiate milk secretion.

The Lactation Hormone of the Anterior Pituitary.—The anterior lobe of the pituitary or hypophysis—a small endocrine gland situated near the brain—is the source of some six or seven hormones, two of which react directly upon the ovary. The researches of numerous groups of workers indicate an addition to their number, namely of a hormone which initiates and is necessary for the maintenance of milk secretion in suitably developed mammary glands.* Extracts containing this hormone which has been variously named "prolactin," "mammotropin" and "galactin," have been prepared by Gardner and Turner,[7] Riddle and collaborators,[8] and Lyons and Catchpole,[9] and some of the extracts seem to be fairly free from other anterior pituitary factors. Little is known of the chemical nature of prolactin; the present indications suggest that it is either a protein or else associated with a protein-like "carrier."

If a castrated immature guinea pig or rabbit of either sex be given a series of injections of oestrone and progesterone until the development of the mammary glands is such that milk secretion would be expected given the necessary stimulus, a copious secretion of milk results upon replacement of the above named injections by a course of injections of prolactin. Lactation in such experimental animals can be maintained for considerable periods if the prolactin treatment is continued.

It is therefore apparent that the lactation hormone of the anterior pituitary supplies the stimulus which initiates lactation. Further evidence that the pituitary is necessary for lactation is afforded by the fact that pregnant animals from which the pituitary has been

* There has been some difference of opinion as to whether anterior pituitary extracts can, in addition to initiating lactation, cause development of mammary glands from which ovarian influence has been removed. Corner (*Amer. J. Physiol.*, **95**, 43, 1930) found that injection of alkaline extracts of anterior pituitary into adult, spayed rabbits which had never ovulated, produced mammary development followed by copious lactation

removed during pregnancy do not lactate.[10] A possible mechanism by which the pituitary is caused to release the lactation hormone into the blood at the appropriate time has been suggested by Smith and Smith.[11]

The Hormone of the Adrenal Cortex.—The adrenals are well known as the source of the hormone adrenaline (or adrenine) which originates in that portion of the adrenal called the medulla.

Another region of the adrenal, the adrenal cortex, appears to be essential for life since adrenalectomized animals can only be kept alive if cortical extracts are given. Brownell, Lockwood and Hartmann[12] claim to have found a method of making cortical extracts which will keep adrenalectomized animals alive though they fail to rear their young, presumably because of faulty lactation. By adding the missing cortical material to such extracts, their power of supporting lactation is restored. There is thus some evidence of the existence in the adrenal cortex of a hormone essential for lactation, though it is doubtful whether there is yet sufficient certainty about this matter to justify the application of the name "cortilactin" to the alleged hormone.

The Thyroid Hormone.—Graham[13] working in Toronto, and at Shinfield, has shown that thyroxine, the hormone of the thyroid gland, exerts a profound effect on lactation. His experiments showed that feeding dried thyroid gland, as well as thyroxine administration, increases both the milk yield and the milk fat production of cows in declining lactation. Folley and White[14] have confirmed this work and further demonstrated that not only does thyroxine treatment increase the milk yield and fat content of the milk, but also its content in non-fatty solids. This result may be of considerable significance from the point of view of the investigation of the causes leading to the secretion of milk poor in non-fatty solids, a problem of considerable concern to dairy farmers at the present time. Graham suggested that the effect of thyroxine on milk secretion is to raise its plane, probably in a manner connected with the well-known effect of thyroxine in increasing the metabolic rate. The results of Folley and White indicate that this is very probably true. In their experiments cows in declining lactation were each given fifteen daily injections of thyroxine and when the full effect of the injections had become established it was found that the enhanced milk yield declined at a rate proportional to the rate of decline which would probably have been observed had no thyroxine been given.

Another interesting and unexpected result of thyroxine treatment during lactation is that the concentration of phosphatase (an enzyme which splits off phosphoric acid from phosphoric acid esters) in the

milk is strikingly decreased. Folley and White suppose that mammary gland phosphatase is necessary for the synthesis of milk and that the demands of the increased milk flow resulting upon thyroxine treatment leave very little superfluous enzyme to be excreted from the mammary gland in the milk.

Conclusion.—The present position in this field may be summed up as follows. The development of the mammary gland appears to be controlled by the ovarian and corpus luteum hormones while the initation of milk flow is probably under the control of the anterior lobe of the pituitary. The thyroid hormone seems to be one of the factors governing the quality of the milk and the rate at which milk secretion proceeds.

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MASTITIS IN RELATION TO CHEESE-MAKING*

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Many cheese-makers are still unaware of the significance of mastitis in a herd when the milk is used for the manufacture of cheese, but the fact that "mastitis milk" may exert a deleterious effect on the cheese has been known for at least fifty years. As long ago as 1888 Hess *et al*[1] emphasized the damaging effect of infected milk on cheese-making, and noted that such milk had a higher albumin, sodium and chlorine, and a lower fat, sugar, phosphate, potassium and calcium content than normal milk.

It is probable that mastitis is far more prevalent than is generally realized. Indeed competent observers have stated that, from the economic standpoint it may be ranked among the first three causes of loss in our herds. Stableforth,[2] who mentions over-stocking and incomplete stripping as factors in the aetiology of the disease, states that 10 to 80 per cent. of herds are infected, the lowest incidence being found in small herds of young cows. The estimated average is from 30 to 40 per cent. of a herd, and the loss of milk stated to be about 100 gallons per cow per lactation.

Hadley and Frost[3] in America, carried out a six months' investigation of a well-managed herd, and found that mastitis was present to the extent of 40 per cent. It may be emphasized that these workers point out that the actual conditions prevailing in a herd are only revealed when repeated examinations are made.

Mastitis is a general term that includes a variety of conditions. The most common type—the ordinary chronic streptococcal mastitis—accounts for 70 to 90 per cent. of cases according to the general findings of bacteriologists. Hucker[4] has reported, however, that only 39 per cent. of 234 cows showing a clinical history of mastitis actually discharged streptococci. Wolf[5] states that 10 to 50 per cent. of udder disturbances were not due to bacterial infection. It is evident therefore that the term "mastitis" has a significance which is coloured by the interests of the investigator. To the bacteriologist it means the presence of numbers of *Streptococcus mastitidis* (or less frequently *B. coli*, *Staphylococcus* or *Corynebacterium*) and cells, to the clinician an udder that is palpably abnormal, to the cytologist the presence of fibrotic tissue, to the chemist increased chlorine and whey protein and decreased lactose and hydrogen-ion concentrations,

*Based on a paper read to Dairy Committee, December, 1935.

to the farmer a loss in milk yield and to the cheese-maker the likelihood of inferior cheese.

The various faults in cheese that have been attributed to mastitis may conveniently be considered at the various stages in the making and ripening processes at which they become evident.

(1) *Slow Acidity or Slow Starter.*—This problem has already been reviewed in this Journal.[6] It will, therefore, only be necessary to mention that not all investigators agree that mastitis is a cause of slow starter. Workers at Auchincruive,[7] Bristol[8] and Reading[9] have reported that the mere presence of mastitis milk does not inhibit the growth of lactic acid bacteria and may even stimulate it. A reasonable explanation of the apparent discrepancies lies in the possibility that two quite different types of abnormal milk have been confused. The ordinary chronic type of streptococcal mastitis frequently results in milk having an increased cell and bacterial content and permitting rapid growth of lactic acid bacteria when these are present. It is probable that this is the type investigated by the workers mentioned. The quite different behaviour of certain abnormal milks such as that reported by Leitch[9] indicates a different type of milk, able in quite small concentrations to inhibit starter activity. Such milk is, fortunately, rare but may be devastating in its effect, especially as it is apparently indistinguishable from normal milk. This type of milk was encountered in Somerset by Miss Stubbs,[10] who states:—

> "With regard to the manufacture of Cheddars, when working among the Cheddar-makers of Somerset, 1905 to 1913, I did, on several occasions, come across cows with a certain form of udder trouble, causing an abnormal milk with an abnormal smell. The milk from one quarter was so affected that it was sufficient to spoil up to 100 gallons of milk, imparting a characteristic smell to the whole. This milk was invariably of a slow-working type. The vats containing the same supply of milk would be normal the following day when the milk from the affected quarters was omitted "

It is evident that such milk contains substances strongly bactericidal to the starter organisms. Unfortunately we have no knowledge of the nature of these substances. Dibbern and Lembke[11] found that lactic acid bacteria grew slowly in milk deficient in casein and calcium, high in albumin and globulin and having a high *p*H and low rennet value. Eighty per cent. of their samples came from "mastitis" or "abortion" cows.

(2) *Weak Curd or Poor Coagulation.*—All workers agree that mastitis milk yields a "soft curd." Hill and Merrill[12] have stated that a "hard curd" milk is particularly advantageous in cheese-making, resulting in a good yield, body, flavour and keeping quality.

The work of Welch and Doan[13] provides interesting data on this point. They found that soft curd milk contained less than 2 per cent. casein whereas hard curd milk had more than 2·6 per cent. They are careful to point out that a soft curd does not imply that the milk came from a diseased udder, although infection lowered the curd tension.

TABLE I.

No. of cells per ml.	No. of cows.	Curd tension g.*	*p*H.	Chlorine per cent.	Brom thymol blue positive per cent.	Soft curd per cent.*
0–150,000	94	44·3	6·56	0·12	5	18
150,000–500,000 ..	35	40·9	6·62	0·13	8	29
500,000–1,000,000 ..	14	35·7	6·62	0·14	8	43
1,000,000–5,000,000 ..	16	36·9	6·63	0·158	8	50
> 5,000,000	7	26·3	6·73	0·176	36	71
Average 900,000 ..	166	41·3	—	0·131	5·3	28·3

* A curd tension of 33 g. or less is considered to denote a soft curd.

Weisberg *et al*[14] agree that soft curd results from a low casein concentration, and have found that a hard curd results from high calcium and phosphorus, but that the whey constituents have no effect. According to them the curd character is controlled by the fat, casein and calcium phosphate.

In cheese-making one of the most important factors is the time taken for the setting or coagulation of the milk with rennet. Sommer and Matsen[15] have shown that sub-clinical mastitis causes a lower curd strength and a slower coagulation time. (The latter is also reported by Koestler.[16])

TABLE II.

	Infected milk.	Normal milk.
Curd strength	23·7 g.	45·4 g.
Coagulation time ..	43·8 mins.	9·7 mins.

Hansen *et al*[17] reported that whereas streptococcal infection invariably lowered the curd strength, staphylococcal infection did not appreciably affect it.

According to Vuillaume[18] the slow rennetting times of abnormal milk are due to a high *p*H and not to a deficiency in calcium. It has been established by Brown and Price[19] that the curd character is controlled by the hydrogen-ion concentration and not the titratable acidity. A high initial *p*H and abnormal composition or buffering value will, therefore, not only result in a poor coagulum but also in misleading titratable acidity values. The change of rennetting

time with pH is very marked at the pH at which the milk is rennetted in cheese-making (about 6·4 to 6·5), a slight increase in pH resulting in a comparatively enormous lengthening of the time required for clotting.[20]

(3) *Abnormal Fermentation in the Early Stages of Ripening.*—As early as 1893 Freudenreich, Guillebeau and MacFadyen[21] had shown that the "blowing" or gassy fermentation of cheese could be traced to infected udders. The causative organism was apparently of the *coli-aerogenes* type. In addition a micrococcus was alleged to be the cause of sponginess and blowing in a skim-milk cheese, resulting in the growth of moulds in the interior of the cheese.

A little later, in 1899, Moore and Ward[22] detected a relation between gassiness in cheese and the presence of organisms causing mastitis. Generally speaking the higher the bacterial count of the milk, the greater is the likelihood of bacterial faults, such as gassiness, in the resultant cheese. Thus Prucha[23] found that diseased udders frequently had a high bacterial count, but as a generalization this has been rather discredited by Wolf[5] who obtained very variable counts from milk taken from abnormal quarters.

(4) *Over-Acidity and Faults in Texture* (*Openness*).—According to New Zealand investigators[24] openness is controlled by the manner of development of acidity in making, irregularities leading to openness. It is evident therefore that "slow starter" and "slow drying out" of the curd may lead to faults in texture, which are frequently followed by discolourations of the type stimulated by the presence of air. An interesting experiment showing the influence of mastitis in this latter respect was carried out by Stubbs and Morgan,[11] who state:—

"A survey of the cows in the herd on this farm was made to detect the number of cows suffering from chronic mastitis.

"The milk of the cows suffering from acute or chronic mastitis—(other of course than those whose milk would be considered unfit for human consumption) was placed in a separate cheese vat. The milk of cows proved to be free from this form of udder trouble was placed in a control vat. Both vats were worked in a similar manner so far as the nature of the milk permitted.

"The difference in the 'workability' of the two milks was very marked.

	Mastitis milk.	Control.
Acidity (titratable)	·18%	·19%
Rennet test	34 sec.	24 sec
Time of coagulation.. ..	$1\frac{1}{2}$ hr.	1 hr.
Conditions of coagulum ..	Very soft, almost flocculent.	Normal
Acidity from press	1·2%	1·35%

"The mastitis milk eventually yielded a more acid cheese, owing to its higher moisture content.

"The experiment indicated that the mastitis milk gave a much slower rennet test and produced a very much softer and weaker coagulum than that of the normal milk and which resulted in a curd that drained more slowly and was never sufficiently dry to make the best type of Lancashire cheese. The experimental cheese were examined at 3, 6, 9 and 12 months, and from the beginning, considerable differences in the process of ripening in the two cheese were evident.

"At every examination the cheese made from mastitis milk revealed brownish discolouration, whereas the control cheese were normal in colour. The difference became more marked with age, until at 12 months the 'mastitis cheese' was a rusty brown colour throughout. The control cheese showed only slight localized discolouration."

Discolouration of this type may be caused by mould growth, the opening of the curd permitting the access of air necessary for the growth of these types of micro-organisms. Normally the reducing conditions in the interior of hard cheese are so intense that aerobic chromogenic micro-organisms cannot thrive.[26]

A similar discolouration has occurred in Cheddar cheese this season.

(5) *Off Flavours.*—Leitch[27] has described a case of burnt or caramel flavour in milk, which was due to organisms of the *Str. lactis* type traced to an intramammary infection of seven cows in a herd of thirty-seven. Clearly it would be dangerous to use such milk for cheese-making.

Chemical Aspects of Abnormal Milks—Variations in Chemical Composition.

(a) *Colostrum* secreted up to three to five days after parturition is obviously unsuitable for cheesemaking. A typical analysis for such milk is as follows[28]:—

Table III.

	After parturition.	4 days later.
Total protein	12·24	3·35
Lactose	2·74	4·22
Casein	4·86	2·15
Albumin	1·45	0·59
Globulin	5·32	0·26
Fat	2·3	5·63

(b) *Milk of Late Lactation* is characterized by a decrease in solids-not-fat and lactose and an increase in protein (both casein and albumin), chlorine and calcium. Milk of this character yields a hard curd, although in some ways it resembles mastitis milk.

(c) *"Severe Mastitis" Milk.*—Such a milk may have a composition approaching the following:—

TABLE IV.

	Severe mastitis Per cent.	Normal Per cent.
Total solids	7	12
Total protein	5·5	3·5
Lactose	Trace.	4·8
Fat	0·3	4·0
Chlorine	0·3	0·08

(d) *"Ordinary Mastitis" Milk* from a cow which is showing signs of recovery from an acute attack may yield data as follows:—

TABLE V.

	Ordinary mastitis Per cent.	Normal Per cent
Total solids	18	12
Total protein	5	3·5
Lactose	2·5	4
Fat	7	4
Chlorine	0·17	0·11

Broadly speaking the more severe the mastitis the nearer does the secretion approach blood in composition. Chemical differences of the order shown above readily account for the faulty behaviour of the milk when used for cheese-making. Fortunately this type of abnormality may easily be recognized. Those which are apparently normal are more dangerous and Koestler[29] in a very interesting paper describes three types of milk dangerous for cheese-makers.

Type A corresponds to the ordinary English "mastitis milk" and is claimed to endanger the quality of the cheese.

Type B is rare and has no detectable analytical differences from normal milk, but it fails to clot with rennet even after the addition of acid. When however calcium chloride is added a clot is obtained immediately. The phenomenon appears not to be bacteriological in nature, and the milk is normal in catalase and leucocytes and total and soluble calcium. Koestler does not consider this type of milk to be dangerous.

Type C also has a normal analysis but the curd fails to dry out normally. This involves stirring for a longer time. While the setting time is normal, the "gelling" is slow, resulting in a general delay throughout the process. A decided improvement was obtained when calcium chloride was added. The presence of 5 to 10

per cent. of this milk in normal milk produced a detectable change in the behaviour of the curd, and it must therefore be considered dangerous in cheese-making.

DETECTION OF MILKS ABNORMAL FROM THE CHEESE-MAKING ASPECT.

It is obvious that the factory maker must go to the farm for the purpose of detecting and eliminating abnormal milks. The simplest test is the ordinary brom-cresol-purple paper test. The black sieve cloth or strip cup can with great advantage be used to supplement the brom-cresol test since together they detect a high percentage of abnormal milks. It is important to realize, however, that the milk of cows in late lactation often gives a positive brom-cresol reaction in the absence of a pathological condition and that very acid reactions to brom-cresol often indicate mastitis. Suspected milks may with advantage be subjected to the rennet test as recommended by Koestler.[29] No simple test that will permit the detection of the presence of abnormal or "mastitis" milk in the mixed bulk is known. It is obvious that although plating on blood agar will demonstrate the presence of haemolytic streptococci, this method is unsuitable for routine work on the farm.

Conclusions.—It would be impracticable to exclude from the cheese vat all milk from cows suffering from mastitis in the technical sense, as this would entail a loss of anything up to 50 per cent. or even higher of the bulk. Milk that is visibly abnormal should certainly be excluded. Milk which reacts positively to the strip cup or to the brom-cresol-purple test or both should also be regarded as abnormal until it can be proved that it may be used with safety. The proportion of "mastitis milk" not revealed by those tests should be reduced as far as possible by the methods advocated by Stableforth.[2] Should trouble continue to exist after these precautions have been observed the only remedy is to ascertain the source of the troublesome milk by examination of the milk of individual cows. A method of the type suggested by Cox[30] may be recommended for this purpose.

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NOTE ADDED 4TH NOVEMBER, 1935

Since the above paper was written, a paper by Minett and Martin on the influence of mastitis and *Br. abortus* infection on the milk yield of cows has appeared (*J. Dairy Res*, 1936, 7, Part II).

The following statements may be quoted from the authors' summary of their papers:—

"When all the lactations of all cows were considered, the average reduction in yield per lactation was 954 pounds due to mastitis. . ."

"Among the Ayrshires of one herd the average reduction due to mastitis was 892 pounds. Among the Friesians forming the second herd, the average reduction was 1,602 pounds due to mastitis. . . "

"Among the Ayrshires mastitis reduced the corrected yield on an average by 10·8 per cent.; among the Friesians the percentage loss was higher, averaging 16·5 and 19·5 respectively in the two herds."

POULTRY

OBSERVATIONS ON POULTRY DISEASES*

By J. S. Garside
University of Bristol

Mortality figures of laying trials and commercial flocks have during the past few years shown an alarming increase, and are the subject of great concern amongst poultry keepers and educational workers. This increase has come about with great rapidity and admits so far of no satisfactory explanation. In common with other centres, we have made an examination of post-mortem results from laying trials and commercial flocks in the Province in an endeavour to obtain information on the prevalence of the various diseases to which the flocks are subject. A review of post-mortem results obtained in the laboratory indicates that roughly 40 per cent. of adult birds succumbed from non-specific causes, i.e. egg-bound, egg peritonitis, crop and gizzard bound, pneumonia, etc.; 32 per cent. were due to intestinal parasitism, and only 7 per cent. to bacterial diseases, of which the most common was tuberculosis. Amongst chicks, losses due to mismanagement accounted for 39 per cent., to bacillary white diarrhoea for 37 per cent., and to coccidiosis 14 per cent.

Intestinal parasitism presents the most serious problem, apart from the losses due to constitutional conditions; it may be that intestinal parasitism is indirectly responsible for increased losses from non-specific causes as a result of lowered vitality due to infestation at some period or another during the bird's existence, especially during the growing stage. Alternatively, is the presence of parasites an indication of an already lowered resistance to infection? It has been demonstrated many times that various animals and fowls can live and thrive while harbouring considerable numbers of intestinal parasites, but these animals have had certain circumstances in their favour. They have not been subjected to infection while still undeveloped. They have had comfortable, warm, dry housing and adequate feeding, and have not been overcrowded.

Do these circumstances apply to our poultry flocks? They do not. The worst, and still the most common fault of the poultry

* Summary of paper read to Poultry Committee, July, 1935.

farmer, is that he overcrowds his stock in appliances and on the land, from the moment they are hatched.

When dealing with bacterial diseases one is able to prevent re-infection by blood testing and removing carriers, or by vaccinating the survivors and making them immune to infection until the organism has died out. Neither of these remedies can be adopted when dealing with parasites, and it is because of the continuous re-infestation that the diseases are difficult to eradicate.

Every worker amongst poultry can cite instances such as the following:—New premises were acquired, remote from any other poultry farm, and equipped with new apparatus in every detail. Purchased day-old chicks from blood-tested stock were placed in the batteries and thrived until at the end of eight weeks, having gone through the cooler battery, they were placed in pens on the floors. (In this particular instance, the chicks being reared for table, were not placed on range, but housed in pens under the one roof.) Signs of coccidiosis were constantly looked for, as it was thought that under these circumstances the disease could not possibly occur, as there should be no avenue of infection. Coccidiosis, however, made its appearance at the end of sixteen weeks in the second batch of chicks, and the probable avenue of infection was in the foodstuffs, delivery of which was in old used bags. But the disease gained a hold by the overcrowding of the chicks in the batteries and afterwards in the pens, although only two-thirds of the recommended number were accommodated in the batteries. At the present time, although washing and disinfection with a blow-lamp is carried out on the battery and pens between each batch of chicks run, the disease cannot be said to be under control, as there is a steady insidious death-rate which only becomes apparent when the numbers are checked, and periodic high losses in one or two pens.

Such instances have been constantly encountered, and the type of floor, slatted, wire or litter seems to make little difference.

Accompanying overcrowding in all types of brooder houses is inefficient ventilation and lack of air space. On several occasions when approached for advice on this subject, the figures recommended by Mackenzie and Russel and quoted by Linton in *Veterinary Hygiene* have been adopted with marked success.

The maximum movement of air through a house, I am convinced, should not be more than four times per hour. Chickens are amazingly susceptible to draughts, and rapid movements of air through the brooder house are to be avoided. In most brooder houses it is impossible to supply all the fresh air required with

only four changes, as the cubic capacity of the house is too small. In calculating the air space required for chicks, from day-old to six weeks, it has been assumed that two chicks equal one adult fowl in their carbon dioxide excretion. This question of ventilation is really important, and there is no doubt that lack of fresh air during the brooder stage has been responsible for untold damage to the health of young stock.

The other point in this most critical period of the chick's existence is the feeding. With overcrowding there invariably occurs lack of trough space, with its consequent disadvantage to the weakly ones in the batch, who cannot get near the food. Infection is concentrated round the troughs, although this is offset by wire floors on which they can be placed. It is impossible now to go into the merits and demerits of dry-mash feeding to young chicks and growing stock. Apart from other considerations the amount of mash passed through the intestines in an undigested state cannot be anything but detrimental to the functions of the intestine, until finally it creates an inflammatory condition favourable to infection by parasites.

There are other indications that the feeding of intensively reared chicks is faulty. The number of cases of deficiency conditions is growing. Ricketts is common, due to lack of green food or cod liver oil, and in other cases to mineral imbalance or complete lack of minerals. On several occasions, leg weakness, associated with deficiency of vitamin B_2; "slipped tendon," due to the high bone meal content of the ration; and other conditions associated with lesions of the eyelids and beak, simulating pellagra have been encountered, and point to the fact that where intensive rearing is concerned a great deal more work must be carried out to determine the requirements of growing chicks.

It is during this period that the future bird is made or marred, and attention should be directed to improving the conditions on the lines indicated. These, of course, do not absorb all the possibilities, but would certainly prove excellent points with which to commence.

FARM POULTRY KEEPING*

By H. H. Duckett

Chief County Poultry Instructor, Somerset

As most poultry keepers are well aware, the pre-war management of poultry stock on the general farm was very haphazard, and to a certain extent it is so to-day. Flocks were mostly kept in the farmyards, scratching and feeding amongst the manure heaps during the day, drinking from liquid manure pools, laying their eggs in any place they could find but a nest box, and perching all over carts and implements in open sheds and barns during the night.

On a number of farms there were two other kinds of housing, the old wheeled field house and the small combined portable house and covered run. Hatching was done by means of the broody hen, supplemented by stolen nests. The feeding was very elementary, fowls merely getting grain fed to them, or feeding on what they could pick up in the stack yards, supplemented by house scraps and what insects they could find.

It was not surprising that, by these methods of feeding and management, the egg production was somewhere about 80 per bird, most of these eggs being laid during the spring and summer months. The general farmer at this period could, in every sense of the word be termed a "poultry keeper"; they certainly did not keep him. As, however, the farmer regarded poultry as something beneath his notice and as a means of supplying his wife with her pocket money for part of the year, it really did not matter much to him, neither did he care.

The stocks at this time were mostly mongrel, although on one or two farms, one could find small flocks resembling Andalusian, Anconas, Minorcas and some of the older type of table fowl.

The usual method of marketing the produce was the once-weekly country town market, or produce was purchased by dealers. Eggs were ungraded and fowls for table were, in most cases, unfinished carcases of either cockerels or old fat hens with flesh of doubtful colour and quality. Small flocks of geese were sold as green geese at Michaelmas; whilst others, along with turkeys, were conscientiously kept for the Christmas trade.

Expansion of poultry stocks on the general farm was noticed about the year 1919, due probably to two causes. Firstly, high prices obtained for produce owing to the shortage and inflated values

* Paper read to Poultry Committee, July, 1935.

of foodstuffs and provisions; inflated currencies naturally affected world markets. Secondly, the educational work carried out by poultry staffs of the various educational authorities.

The new housing and other appliances at this time, due to lack of experience on the part of all concerned, followed closely on the lines of the specialist poultry farmer of that period, the houses being built on the colony semi-intensive type, taking flocks of from 50 to 100 birds each, on free range. Feeding also slightly improved, in that the birds were allowed a wet mash as well as grain, although the methods of feeding were anything but sanitary—being fed mostly on the bare ground—and the consistency of the wet mash was anything from partially dry to a swill.

This era also saw the disappearance of some of the old breeds and also of some of the barn yard type of fowl; due, no doubt, to the advertising of stock by specialist breeders, to the publication of Egg Laying Trial reports and to educational work.

These new methods naturally had the result of increasing egg production slightly, which seemed to have risen approximately 20 eggs per bird.

Although a slight improvement was shown in these directions, management lagged very far behind, the poultry stocks being attended to by anyone on the farm who had a few minutes to spare.

The real expansion on the general farm started about 1924, and was helped a year or two later by the introduction of a house which resembled, to some extent, the old field wheeled house with this exception, that instead of a solid floor, slats were used. This type of housing at the time proved more ideal for general farm work than the large immovable semi-intensive type. It was also cheaper than the older type and the farmer could keep larger flocks with less capital outlay. With this unit being mobile, he was not tied to either any one place in a field or any one field on his farm; nor did he get those bare patches round the house which was the bugbear of the colony house; neither did he get foul ground on which his other stock would not graze.

From 1928 onwards, there was a rapid change-over in the type of poultry keeper. The number of specialists remained stationary and the general farmer poultry keeper greatly increased.

It was not long after this that the folding unit came into being, following the lines of its prototype, the small combined house and run of pre-war days. Being built on modern lines, however, it was far more adaptable to modern farm methods, especially where flat or down land was available.

A change-over in the stock during this period was also showing itself, the general farmer having realized by now that well bred stock was essential for profit making, especially on those farms where large flocks of poultry were being kept. The farmer now using pure bred stock was faced with the question of the surplus cockerel; but with the advent of sex-linked stock his troubles in this direction seemed to be eliminated. The farmer found them a more profitable proposition than the pure breeds, because he had not the worry and trouble of dealing with the surplus cockerels.

Improvements are also recorded at this time of methods of management. Educational workers were beginning to convince the farmer that the poultry stocks on the farm were not an odd-time job, and that irregular visits to the poultry meant irregular feeding, excessive broodiness and sometimes lack of water. An occasional collection of eggs led to dirty eggs and loss due to cracked and eaten eggs. These irregularities naturally led to a loss of profit. It was therefore realized that it was essential that someone, preferably interested in poultry, should take over the poultry stocks on the farm, and so make it a special sideline, in just the same way that cattle, sheep, pigs and crops were special sidelines; and that if profits were going to be made, regular habits must be adopted with poultry as with other stock.

Great strides had been made in methods of feeding. These, however, were still varied and were constantly changing. Wet mash feeding, with the labour involved, practically died out, and was substituted for by either grain and dry mash, or all mash feeding, with an occasional farm where one would find that pellet feeding had been adopted.

Although the farmer had been slow to adapt himself to modern methods, both in plant and management, there are some of us who felt—and who do feel even now—that he had gone to the other extreme with regard to feeding. This is quite clearly shown by adjustments that are being made at the present time. The different systems of housing required different methods of feeding and it was generally found, especially with the folding unit, that continual feeding tended to fatten stock, with the consequent loss of production and excessive broodiness.

The trend at the present time is towards definite meals rather than one continual feed, and these are to-day a combined system of grain twice per day with a dry or wet mash at certain periods during the day.

The educationalist, for some considerable time now, has been trying to make the farmer realize, that if he wishes to make the utmost

out of poultry, this class of stock must be used in conjunction with other sidelines on his farm. In other words, that poultry must be brought into rotation with other stock and crops. Unfortunately the vast majority of general farmers have not taken much notice of these teachings; but there are quite a number of advanced younger farmers who have very suddenly realized that, to make the most out of their poultry stocks, the rotation method is sound.

The advantages of rotation may be enumerated as follows:—

(1) Improvement to pasture and meadow-land with its consequent improvement of other stock products. With the improved mobile method of housing—especially the folding unit system properly managed—the even spread of manure over pasture and meadow-land has improved the grass considerably.

(2) On those farms where cereals are grown there has been less wastage of the cereal, because the mobile units can be placed on the stubble after reaping, which naturally lessens the cost of feeding.

(3) Again, with these systems, the farmer has a small flock under observation at a time and can pick out any birds which are not "pulling their weight" or are in any way unfit to remain in the flock.

The question as to whether the farmer has time to deal with breeding stock and the hatching and rearing of chickens has been a very vexing problem, and here comes the question as to whether this part of the business is really the farmer's job or the specialist's job. To my mind it is a job for the latter, the production of eggs alone being the farmer's side of the question. The farmer would be better advised to replace from 50 to 60 per cent. of his stock each year by half grown pullets. This eliminates all that exacting care and attention and the expensive foods that are so necessary to young stock. He can still make a profit from commercial eggs by buying two to three months old pullets for re-stocking each year.

To those people who have their finger continually upon the pulse of the poultry industry, there can be no doubt in their minds that there is a trend towards specialization. In this there is quite a definite part to play by the general farmer. For some time now specialists' breeding plants have been unable to cope with the demand from the general farmer for really good sex-linked stock. This is surely a sign that the farmer has his eye on the egg production side

of the industry. If this is so, there is plenty of work in the immediate future for those engaged on the educational side.

Young Farmers' Clubs offer plenty of scope for this work. In Somerset we have already started Poultry Classes amongst these young people and find that they are very receptive and willing to learn new, up-to-date methods. They readily realize, where the older farmer does not, the value of poultry in its proper place on the farm. This is definitely shown by their keenness and attendance at lectures, demonstrations and classes. Here they are taught modern methods of housing and how these methods should be used, taking into account other stock and crops on the farm. They are shown why different housing requires different types of mashes and different methods of feeding. In judging classes, they readily pick up the various methods of culling, which is one of the most important aspects of poultry work.

While we have quite a number of farmers who run their poultry on up-to-date lines, especially with regard to rotation, another type of general farmer has appeared who is running on somewhat different lines. I refer to the farmer who owns, or rents, a large grassland farm and rotates his fowls on the grassland only, in the following method:—A certain acreage of ground is ploughed up and seeded down to grass each year. Young pullets are brought in the following year and housed in slatted floors or folding units on this ground. They remain here and do a full year's lay, are culled out at the end of the season and the best birds are still left on this ground. In the meantime, a further acreage has been ploughed and seeded, and young stock is brought on to the land last seeded down, and so on.

To my mind this has a very definite advantage, that of keeping the ground sweet and the stock disease-free. Whether this type of farm will increase can only be a matter of conjecture; but it is certainly a system that has shown profit so far and is well worth considering.

MISCELLANEOUS

FLUCTUATIONS OF POPULATION AMONGST INSECTS*

By A. Roebuck
Midland Agricultural College

The possibility of great changes in numbers in various species of insects from year to year is well known to field entomologists. The difficulty is the measurement of populations.

There is no standard method of sampling. It is necessary to work out a method for each species studied. In some cases egg counts are possible—this is the ideal method. In others larvae, pupae or adults have to be counted. In many cases a colony or nest is the best unit for measurement. The numbers of some species are best estimated by their effects on crops, e.g., destroyed tillers, damaged seeds, etc. Where there is more than one generation a year it is often impossible, owing to overlapping, to count each generation. When the life cycle extends over several years, it is often desirable to separate the successive generations.

There is always the possibility of complication through the question of host plants. A species with a single host plant is the most easily studied. Where there are several host plants, for various reasons one or other may be preferred in any given season. When wild plants are alternative hosts the difficulties are further increased.

When a method of sampling has been adopted there arises the greater problem of the area to be sampled. One would like to know the population over the whole Country, but being restricted to a province, in this case of five Midland Counties, this becomes the maximum area for study. The local distribution of many species often further limits the area to be studied. The easiest to study are those whose host plants are in restricted areas and are long lived plants, e.g., trees.

A great difficulty with farm pests is that the crops change position yearly, and the insects have of necessity to move also. Local migrations and large-scale migrations may disturb results. There

* Paper read to Biology Committee, December, 1935.

may be also special local concentrations of particular species. The ultimate aim is to estimate the summation of the various climatic factors, parasites, predators, diseases, etc.

In studying populations one finds two series of factors involved. Certain insects are scarce for years and then suddenly increase in numbers. What are the factors which produce these irruptions? On the other hand many species are common and abundant for many seasons and suddenly become scarce. What are the factors which cause these rapid diminutions?

The following species are given to represent both these types.

EXAMPLES OF SUDDEN IRRUPTIONS:—

1. *Andrena fulva* (Lawn Bee).—In 1925 there were 153 nests on the lawn in our garden in Leicester. In 1923, 1924, 1926 and all subsequent years to 1935 the number of nests a year has been 0 to 6. This is possibly not important. It may be a habit of this species to concentrate on a piece of ground in any one year and avoid that ground for many subsequent years.

2. *Blennocampa pusilla* (Leaf Curling Sawfly of the Rose).—In 1931 this was abundant everywhere throughout the Midland Province; its numbers were incredibly large. In the years 1922 to 1930, and 1932 to 1935 it has been rare.

Many species of sawflies have this same habit of periods of rarity suddenly broken by a period of extraordinary abundance.

3. *Trochilium apiforme* (Hornet Clearwing Moth of the Poplar).—This is normally a rare species. In a large garden surrounded by poplars in Nottinghamshire there appeared large numbers in 1930. These were from eggs laid in 1930. They were not noticed previously. By counting the emergence holes the population was (in round numbers):—

1932—500, 1933—1,000, 1934—750, 1935—200.

A complication has arisen which will affect the insect. A number of the trees have already been cut down because of Silver Leaf attacks and quite a number of others are infected. The garden is quite isolated and there is every reason to believe that the colony of insects is unaffected by outside influences.

4. *Hylemyia brunnescens* (Carnation Fly).—This normally attacks carnations. The larvae are stem borers. An outbreak occurred near Leicester in the autumn of 1934 where the larvae were leaf miners in Sweet Williams. A number of adults were reared in the

laboratory and pupae were collected in the garden: from these more adults were reared. Over 100 adults of both sexes were supplied with more Sweet William plants but no eggs were laid. They have also disappeared from the garden.

5. *Psylliodes chrysocephala* (Cabbage Stem Flea Beetle).—This insect appeared in immense numbers in the cabbage-plant growing district of the Charnwood Forest area of Leicestershire during the winter of 1934–1935. Previously collectors have obtained specimens of the beetle in Leicestershire, but it has not been a pest (since 1922). A field which should have cropped 3,000,000 plants had the crop completely ruined by the larvae. From counts made in April, 1935, it has been estimated that there could not have been less than 3,000,000 larvae in the field. The total population on three other fields was estimated to be not less than 5,000,000. The adults beetles emerged in June. The whole attack so far is in a well-defined area and it is hoped to study them further.

EXAMPLES OF MORE STABLE SPECIES:—

6. *Phyllodecta vulgatissima* (Blue Willow Beetle).—This species is restricted to the *Salix viminalis* varieties. It has been studied on an isolated block of willows about four miles north of Leicester on the banks of the River Soar, with check areas north and south of this block.

The number of beetles increased in 1919 and 1920 so that it became a serious pest and skeletonised the crop in 1921 and subsequent years.

The adults can be counted on the young shoots during the first week of June and the larvae about the middle of July. Larval counts are roughly five times as large as the adult ones. The adults numbered, in 1922, 13 per rod, or 1,600,000 per acre; in 1923, 12 per rod, or 1,500,000 per acre; in 1924 to 1929, 8 to 12 per rod; in 1930, 7 per rod, or 875,000 per acre. In 1931 and subsequent years it has been difficult to find individual specimens in the area.

The larvae appear to have all perished during the wet weather in July, 1930.

7. *Psila rosae* (Carrot Fly).—The results given apply to field crops on the east side of the River Trent, partly in Lindsey and partly in Nottinghamshire. This species has two generations a year. Larvae of the first generation are sampled in the beginning of July. Larvae of the second generation can sometimes be counted at the end of October, but check counts should be made later, say January and March.

The following are larvae counts:—

In 1925	(1st gen.)	10	per sq. yd.	or	50,000	per	acre.
„ 1926	(1st gen.)	8	„ „	„	40,000	„	„
„ 1927	(1st gen.)	20	„ „	„	100,000	„	„
„ „	(2nd gen.)	30	„ „	„	150,000	„	„
„ 1928	(1st gen.)	16	„ „	„	80,000	„	„
„ „	(2nd gen.)	16	„ „	„	80,000	„	„
„ 1929	(1st gen.)	12	„ „	„	60,000	„	„
„ „	(2nd gen.)	30	„ „	„	150,000	„	„
„ 1930	(1st gen.)	12	„ „	„	60,000	„	„
„ 1931	(1st gen.)	60	„ „	„	300,000	„	„
„ „	(2nd gen.)	40	„ „	„	200,000	„	„
„ 1932	(1st gen.)	24	„ „	„	120,000	„	„
„ „	(2nd gen.)	12	„ „	„	60,000	„	„
„ 1933	(2nd gen.)	8	„ „	„	40,000	„	„
„ 1934	(1st gen.)	4	„ „	„	20,000	„	„
„ „	(2nd gen.)	12	„ „	„	60,000	„	„
„ 1935	(1st gen.)	2	„ „	„	10,000	„	„
„ „	(2nd gen.)	1	„ „	„	5,000	„	„

8. *The Chafer Beetles.*—Four species have been under observation in Lincolnshire and Nottinghamshire. They are very striking during "flight" periods.

(a) *Rhizotrogus solstitialis* (Summer Chafer).—The last recorded swarming or flight period was 1901 in Lincolnshire. It is on the whole a scarce species and has been since 1922.

(b) *Serica brunnea* (Brown Chafer).—This species swarmed in 1910 in North Lincolnshire. Since then there have been few about.

(c) *Phyllopertha horticola* (Garden Chafer).—This species has been studied in Central Nottinghamshire, in the Sherwood Forest area where at times it is a serious pest to the grassland. The area of land specially kept under observation is approximately 40 square miles.

The normal population of larvae since 1928 has been 1 per sq. yd., or 5,000 per acre (3 million per sq. mile). In 1928 the numbers greatly increased. The population in the bad portions averaged 9 per sq. ft., or 81 per sq. yd., or 392,000 per acre, or 250 million per sq. mile. By 1931 the numbers had increased to 12 per sq. ft., or 108 per sq. yd., or 520,000 per acre, or 320 million per sq. mile. In places the numbers were 24 per sq. ft., or over 1 million per acre. The area occupied by the very bad attacks was approximately one-quarter of the area studied.

It will be noticed that the severe outbreak lasted from 1928 to 1931. It is interesting also to note that the records of a farmer in the middle of the area showed that the same fields were attacked in 1898 and following years, that is 30 years previously.

(d) *Melolontha vulgaris* (Cockchafer).—Whereas the life cycle of *Phyllopertha* is completed in one year, that of *Melolontha* appears to take four years in Nottinghamshire. The problem of abundance or scarcity is complicated in this species by the fact that the larvae are practically all the same age in any one year. This results in the adults appearing in numbers one year and being absent for the next three years. The population study, therefore, since 1928, has virtually resolved itself into a life cycle study.

The area studied was a little north of the *Phyllopertha* district. Arable crops are commonly attacked. 1928 and 1932 were pest years, when the larvae were destructive (2 to 5 sq. yd., or 10,000 to 25,000 per acre). Smaller larvae were abundant in 1931 and 1935 (4 to 8 per sq. yd., or 20,000 to 25,000 per acre). 1930 and 1934 were flight years for the adults and eggs were laid. 1929 and 1933 were resting years.

There is a small population which does not conform to this regular cycle.

9. *Pegomyia hyoscyami var. betae* (Mangold Fly).—This was studied on the Wolds in the North of Lincolnshire. Egg counts in May would seem to be the ideal method of estimating the numbers of this insect, but unfortunately they do not always seem to be laid on the seedlings. There are two or three overlapping generations which render larval counts uncertain of interpretation. An estimate of the numbers of this species has been obtained by the percentage loss of leaf surface in September.

Experiments were made at the same time to find the loss of crop resulting from their attacks. A 50 per cent. defoliation at the end of May causes 20 per cent. loss of crop, whilst a similar defoliation in mid-September, causes 5 per cent. loss of crop.

The percentage of leaf surface lost was:—

1925	..	0·1%	1931	..	8%
1926	..	6%	1932	..	7·5%
1927	..	3%	1933	..	4%
1928	..	3%	1934	..	2·5%
1929	..	50%	1935	..	0%
1930	..	50%			

It will be seen that 1929 and 1930 were the only years when this was a pest. 1923 and 1924 were also pest years, but no actual figures are available, only general notes.

THE MUSK-RAT CAMPAIGN*

By B. Vallings
(*Chief Trapper to Ministry of Agriculture and Fisheries*)

When one looks at the map of Shropshire and the surrounding counties and tries to count the number of pools, ditches and rivers on the one inch to the mile map, it seems an almost impossible task. Discarding this, and taking the six inch to the mile map, one would find small pools dotted about on almost every other square inch, each of these being a possible hiding place for a musk-rat. So when the campaign against the musk-rat was started these maps were used, each pool being searched carefully for traces, and when it was found that a lot of these did in fact harbour musk-rats, the task of extermination seemed almost impossible without a vast army of experienced trappers.

The rivers Severn, Vyrnwy, Morda, Perry, Rea Brook, Tern, Roden and mouth of the Worfe, were found to be infested. Rats were killed as far north as Whitchurch, Meifod Bridge in the west, Wellington in the east, and Gloucester in the south-west. Over twenty-five rats were caught in the Bridgnorth area and below Arley.

Reports of the presence of musk-rats came in from almost every county in England and Wales, which had to be investigated from time to time; this weakened the slender force of men considerably. More men had to be trained to search, and catch the musk-rats. Probably one of the greatest difficulties was the making of good river men, since the Severn, especially when in flood, is not an easy river on which to teach men. Such places as Baggymoor, on the upper reaches of the Perry, where many ditches intersect, were most difficult to contend with; during the migration seasons, spring and autumn, they were a nightmare to the trappers, as in between these seasons they appeared to be quite free of rats; then, after a short period, the musk-rats would appear again from seemingly nowhere.

One's imagination could plainly see the rats gradually spreading further afield as time went on. A series of ditch and plank traps of the floating type were designed, and were put in this area, which proved effective and stopped the migration northward. During the exceptionally dry summer of 1934 a large number of pools seemed to be quite clear, the trappers reporting week after week,

* **Substance of a paper read at P.R.C., December, 1935.**

"No signs found." But in some cases they were wrong. Lacking experience of the cleverness of the musk-rat, and the way in which he adapted himself to dry conditions, it was found in some cases, where a pool had gone nearly dry, that the musk-rat had deserted his old burrows and gone down to a much greater depth below the mud, with perhaps, only one entrance hole well out in the centre of the pool, amongst pond weed and water-lily plants, making it most difficult to find him. The same thing happened in ditches that had gone dry. He made burrows the whole length of the ditch—perhaps 150 yards—underneath the mud, with an occasional air-hole, cleverly concealed. This habit was not easy to combat.

The straggler or migrating rat was also difficult to catch; he would swim for miles, landing only occasionally, hunting for a mate and to feed and rest. A trap was designed that jutted out a long way into the water from the river bank; this trap was also of the floating variety and would rise and fall with the stream. It was of great value, it was fool-proof, caught well and drowned the rat immediately.

In the Severn itself many difficulties arose; the large number of trees bordering the banks, their roots sticking out into the water, made a perfect hiding place for wise old rats, as it was almost impossible to gas or trap these strongholds. After heavy storms in the Welsh mountains the water rose and fell very quickly, disturbing the methods of setting traps. A motor boat, running from the mouth of the Vyrnwy to Shrewsbury, enabled two men to look after a very large number of traps.

Some burrows were found to be over 40 feet in length, running right up into gardens bordering the river; livestock walking the river bank broke into these and on more than one occasion, cows' legs were broken.

One incident happened which would have been amusing if it had not caused considerable damage: a gentleman built a dam across a stream to operate a hydraulic ram; for some mysterious reason the water suddenly lowered, and would not drive the ram. It was found later that musk-rats had burrowed beside the concrete, and the water had seeped through to a lower level. Musk-rats also caused the Perry to break its banks above a mill, and one morning when the men came to work, there was no water to turn the wheel. They also cut a large amount of water weed in the upper reaches, for winter storing, much of which floated down stream and clogged the mill wheel.

Near Meole Brace the musk-rats actually burrowed into a railway embankment, but luckily they were found and caught

before doing much damage. In Germany, several bad train wrecks were caused by the track giving way through their burrowing underneath it.

Besides Shropshire and the surrounding counties, we had Surrey, Sussex and Hampshire to contend with. The Arun proved a most difficult river on account of the tides; a type of trap, very similar in construction to the old eel basket, only much larger, and with guards at the double ends to prevent the musk-rats swimming out again, was found effective. Here again, the floating ditch trap proved its value. The Amberley Wild brooks were an ideal hiding place, many miles of ditches, overgrown with rushes and pond weeds, proved a veritable paradise for rats, and the same ditches had to be tramped week after week, and month after month, to see that no migrating rats had started a fresh colony.

A musk-rat was reported killed in a battery factory at Alton. After many weeks of searching a number of musk-rats were found in the vicinity of Farnham on the Wey, a number of pools in the neighbourhood were also found to be infested; a large, treacherous swamp of quaking bog seemed to be a favourite haunt, and in the autumn and spring the musk-rats would take advantage of its wonderful cover, and hide there. In this quaking bog, bordering the River Wey, they made burrows underneath the moving vegetation, to a depth of 2 feet: with a 10-foot pole, pushed down through the surface, one could not touch bottom. Their burrows were in the soft banks; when traps were placed in them the soil was so soft that the rats, suspecting the presence of traps, made other burrows to avoid them. Gas was used here to drive the rats to the centre of the pool, where they were caught on carefully camouflaged floating traps.

No rats have been caught in this area for a considerable period, and it is sincerely hoped that no new infestation will be found.

The adaptability and conscientiousness of the men employed on sometimes dangerous work, especially on the River Severn and marshes like the above, has been an important factor in accomplishing these results, especially when it is considered that few of them had had any previous experience of this kind of work.

In the writer's opinion, it will be some years before it can be said with certainty that there is not another musk-rat in England.

A SURVEY OF 25,000 ACRES OF LAND WITH SPECIAL REFERENCE TO ITS LACK OF LIME*

By A. W. Oldershaw, M.B.E.

County Agricultural Organizer for East Suffolk

In East Suffolk, as in many other counties, we have a large area of land which is seriously lacking in lime. In our case this land is mostly of a light or mixed soil type—we have very little heavy land in this condition. In 1925 we started a Light Land Experimental Station at Tunstall on a light sandy soil having a lime requirement of about 27 cwts. of calcium carbonate per acre. Half a field was chalked, at the rate of 5 tons per acre and suitable half-acre plots in duplicate across chalked and unchalked land were cropped with a light land rotation, suitable manures being applied to each crop.

It was found that the chalked land gave, over a complete rotation of four years, crops worth £18 per acre more than those on the unchalked land. After paying for the initial chalk (which cost 50s. per acre including spreading), an increased monetary return of nearly £4 per acre per annum was obtained with a yield of 180 per cent. per annum on the capital invested in chalking.

These results are so striking that large numbers of farmers annually visit the plots and there has been a tremendous revival of the practice of chalking. I may say that we are fortunate in possessing an inexhaustible supply of very soft chalk near Ipswich, in some parishes we have deposits of "crag," a shelly material containing 20 per cent. to 80 per cent. carbonate of lime, whilst we also have sugar beet lime sludge available. We are thus well provided with an abundant supply of the cheap and bulky forms of lime. With the aid of the modern motor lorry we can now give a good dressing of either chalk or sugar beet lime sludge within twenty miles of the chalk pit or sugar beet factory for £2 per acre. It was recognized, however, that we had no definite information as to the amount of land which needs some form of lime.

It was suggested that if we could arrange for a survey of a small district, much useful information might be obtained. It was also thought that the surveyor by his personal contact with the occupiers of land in the course of his visits would be very likely to advance their knowledge of the subject and to encourage them to use some

* Paper read to Agricultural Committee, December, 1935.

form of lime where needed. It was therefore decided that a local agricultural student (Mr. F. W. Dunnett) who had worked on the land for about ten years and was thoroughly conversant with the district should be asked to undertake this survey in his holidays.

He visited every field of agricultural land (but not woods, parks or building land) in twelve parishes in company with the occupier or his representative and made notes regarding cropping, weeds, etc. In all, he took 208 samples for testing at the School of Agriculture, Cambridge, at the rate of about one sample per 100 acres visited. All fields were divided into four groups according to their apparent lime status as judged by either lime requirement tests or an opinion based upon a combination of ascertained crop failures or successes, weeds, appearance of the soil, presence or absence of nodules of chalk or shells of "crag," the presence of a mat of undecayed vegetable matter in the case of grass land, and litmus tests (the latter admittedly very imperfect, but undoubtedly of some use, as is indicated by the very considerable degree of agreement between them and the lime requirement results from Cambridge). It was recognized that it would be impossible to do lime requirement tests of any but a small proportion of the fields visited.

My own view is that an experienced man can tell sufficiently near for all practical purposes by simple inspection and enquiry whether land requires a dressing of any form of lime or not, in at least nine cases out of ten, especially when he comes across complete failures of crop from this cause as was very often the case in the survey. His task is of course rendered much easier if the land has been unploughed for sufficiently long to enable the weeds to grow.

As soon as the information was available a report on every farm was sent to owner and occupier, special attention being called by means of underlining to those fields which required dressing of some form of lime. A circular letter was sent in each case giving advisory notes regarding the cheapest forms of lime in the district, weeds as indications of acidity, etc. The results indicate that in the twelve parishes completed we have:—

Total area of twelve parishes, 24,934 acres.

Area of crops and grass as given by the Ministry of Agriculture, 16,821 acres.

Area sufficiently lacking in lime to reduce the yield of crops such as sugar beet and barley to the extent of probably 20 per cent., 3,305 acres.

Area so seriously lacking in lime as to greatly reduce the yield of sugar beet and barley and sometimes to cause complete failure, 2,549 acres.

Area showing extremely serious lack of lime—sufficient to cause complete failure of sugar beet and barley in most seasons, 1,237 acres.

Total area lacking in lime equals 7,091 acres.

The area of woods and parks in the twelve parishes is 2,557 acres. There is quite an appreciable area of what Sir Thomas Middleton calls "the wasted land of England" in the district. There is very little of this, however, which could not be cultivated or treated as grass. The wasted land has usually been cultivated in the past, but has been allowed to become covered by broom or gorse, owing to its alleged poverty or owing to the depredations of vermin, etc. The "poverty" usually means lack of lime or lightness of the soil or both.

Much of the land is relatively good and the area is essentially rural, with only a small proportion of building land. In East Suffolk we have 430,000 acres of agricultural land, of which probably 200,000 acres are light or mixed soil and consequently likely to be poor in lime.

If we only take a quarter of this as seriously lacking in lime (undoubtedly from the above figures a serious under-estimate) it would appear that we have about 50,000 acres of land with its productivity greatly reduced from this cause. We have previously seen that at Tunstall on this type of land an increased monetary return of nearly £4 per acre per annum was obtained by the use of 5 tons of chalk. If we take £2 instead of £4 as applying to the 50,000 acres (undoubtedly again a serious under-estimation) we get a total annual loss to the county of £100,000.

RECENT ACTIVITIES

THE 1935 SUMMER MEETING, BRISTOL

The yearly Conference at Bristol, 1935, attracted some eighty people, and it was particularly appropriate that Professor Hanley should occupy the Presidential Chair on this occasion on account of his early association with Bristol, and more especially as he was the first Head of the Agricultural Advisory Department of the University. It was a great privilege for those of us who worked under his direction at Bristol a decade ago to welcome him back temporarily to the Department which owes so much to his enthusiasm and foresight in those early days.

Since early days Bristol has been associated with pioneers and pioneer-work and therefore the action of Council at the Bristol meeting, in appointing a Special Committee to consider possible measures for improving the status and enhancing the prestige of the Association may not be out of place. This Committee has been entrusted with a big task, but judging from its personnel it should be more than equal to the duties which devolve upon it.

The inaugural dinner, held at Manor Hall, on the 23rd July, was well attended. In the absence of the Vice-Chancellor and the Pro-Vice-Chancellor, Professor Trueman, the Dean of the Faculty of Science, represented the University as a guest of the Association, as did Capt. Douglas Wills, the Treasurer of the Long Ashton Research Station. These gentlemen both added to the enjoyment of the evening by their excellent speeches.

Whilst the usual high standard of papers read before the Association was well maintained, some were of outstanding merit, particularly Mr. Forbes's excellent contribution on the "Marketing of Eggs and Poultry."

In accordance with accepted custom, a number of educational tours of the area was arranged, but owing to the lack of support, the whole day tour in Wiltshire and the special tour organised for those more especially interested in poultry husbandry had to be cancelled. The two half-day tours—the one to the Imperial Tobacco Company's factory and Messrs. John Robinson's Feeding Stuffs factory, and the other through the cheese-making area of central Somerset, the Mendip Hills, Cheddar and Wells, proved to be very

acceptable and it is hoped that these members who supported these tours were repaid for their effort.

The activities of the Imperial Tobacco Company are so well known as to need no further comment, but it may not be out of place to mention here that Messrs. John Robinson, whose first oil mill was built at Avonmouth some 32 years ago became associated with the British Oil & Cake Mills in 1916 and through them with Unilever Limited in 1929. The Oil Mill, which was visited by the Association, can crush about 60,000 tons of seed per annum, while the capacity of the Compound Mill (for balanced rations) is over 100,000 tons. During the winter, which is the factory's busiest time, about 500 men are employed. The Mill is conveniently situated at Avonmouth Dock, so that ocean-going steamers can discharge oil-seeds by means of conveyors and elevators direct into its own warehouses.

The tour through the cheese-making area of central Somerset was made on Thursday afternoon, 25th July. Leaving Manor Hall promptly at 2 p.m. by motor-coach, a surprise visit was paid to the University Research Station at Long Ashton. This involved a detour of a few miles but was well worth while since the members were able to meet the Director, Professor Barker and his Staff and to see them actually engaged upon their many problems in connection with fruit and cider research. There is no doubt that many of the visitors would have liked to have taken the opportunity of such a fine afternoon to make a tour of the plantations and to examine more closely the field experimental work in connection with fruit culture for which this Station is famous. The majority, however, were able to partake of a refreshing drink of cider before being persuaded by various means to enter the motor-coach so that, as far as possible, the original time table might be adhered to.

After leaving Long Ashton, the main road from Bristol to Taunton was regained by proceeding through the pretty village of Barrow Gurney, and continued for a few miles until the north-western edge of the Mendip Hills was reached, via the well-known beauty spot of Burrington Coombe. Time would not permit of a halt by the side of the "Rock of Ages," which is a limestone outcrop and to which a pilgrimage is made by thousands of people during every year. After a steep climb the top of the Mendip range was reached and those present were extremely interested in the moorland type of farming. A great part of this area is devoted to milk and sheep production on rough pastures enclosed by dry stone wallings. In Roman times parts of this district were mined for lead, and such areas are now dangerous to horses, sheep, cattle and poultry, on

account of the number of disused mines and the presence of galena in the soil. The type of farm is usually small and methods of production are backward, but the Mendips have given their name to a breed of sheep which, while not important nowadays, was of considerable importance a hundred years ago.

After crossing the Mendip range a long and steep descent was made through the famous Cheddar Gorge with its cliff-like sides of bare carboniferous limestone rock. A short halt was made in the Gorge so that those members with a geological bent might have the opportunity of making a tour through one of the well-known Cheddar Caves in which stalactites and stalagmites of all sizes from the smallest to the largest reflect the colours of the minerals deposited in these hills. From here the route lay south-easterly along the southern edge of the Mendips and members had the opportunity of obtaining a bird's-eye view of the cheese-making area which has given its name to the well-known Cheddar cheese. It was also possible to see for many miles southwards across the northern part of the rich Vale of Taunton, and the contrast between the type of farming on these low-lying lands and that just seen on the Mendips was most striking. In the distance could be made out Glastonbury Tor and the connection between this region and King Arthur and his Knights was naturally brought to mind.

The next step after Cheddar was made at Wells, where members obtained a hurried tea and a hasty look around the Cathedral and the grounds of the Bishop's Palace.

Wells is 20 miles due south of Bristol, and the return journey began by the two-miles-long climb up to the top of the Mendips once more, only this time at a point some ten miles more to the south-east than where this range was crossed on the outward journey. The route back to Bristol lay close to the coal-mining area around the town of Radstock, and those members from the Midlands and the North saw great similarities in the type of farming necessarily carried out in such regions. After a few more miles Manor Hall was reached about 7.30 p.m.

The whole of the local arrangements were in the capable hands of Dr. C. V. Dawe, and with the characteristic thoroughness of an economist he saw to it that everything went smoothly. In order that this could be achieved it was very obvious that he had cast from his mind any thoughts of "randomization"; in point of fact, there were no signs of any form of replication in the excellent plans he had made for the Bristol meeting.

A. W. LING.

THE BRITISH ASSOCIATION MEETING, NORWICH, 1935

Those who had not visited Norfolk for some years noted many changes in the appearance of the country-side when, as members of the Agricultural Section, they took part in the Saturday's excursion to Raynham, Southacre and Swaffham. It is true that there seemed to be no marked diminution of arable land, although milch cows have increased by 50 per cent. above the pre-war figure, and wheat is now back again at its pre-war acreage. But unsubsidized cereals had clearly decreased; sugar beet had mostly taken the place of mangolds and turnips; more potatoes were grown, more fruit and forest planted; there were fewer sheep but far more pigs; and there was much mechanization without, however, any marked depopulation of the villages.

These changes were used by Dr. J. A. Venn to illustrate the subject of his presidential address to the Section on "The Financial and Economic Results of State Control in Agriculture." He began by remarking on the striking similarity between the aftermath of the Great War and the aftermath of the Napoleonic Wars a century earlier. But while the symptoms were the same, the reactions of the State were entirely different. During the earlier period of agricultural depression, financial assistance was negligible; but after the Great War the State (1) rendered first aid by direct subsidies and grants, and by reliefs from taxation, then (2) proceeded to control importation and home production of agricultural commodities, and lastly (3) re-imposed fiscal duties after eighty-six years of free trade.

The President next discussed the benefits that had thus accrued to agriculture through wheat deficiency payments, sugar beet and meat subsidies, milk grants, local taxation reliefs, and grants in aid of small holdings and allotments, agricultural education and research, and afforestation. The cost of these to the State he assessed at £33,750,000 for the year 1934–35. If from this sum is deducted the increase in wages through the establishment of wages boards, estimated at £10,250,000 for the same year, a net gain is left to agriculture of £23,500,000, or, in round figures, some 15s. per acre of the arable and permanent grassland of Great Britain. He then proceeded to consider the reaction of each branch of the industry to the control now exercised by the State, foresaw in the

comparatively near future some relaxation from that control, and expressed his confidence that British agriculture would in the end emerge unscathed but re-modelled.

Speaking in the debate that followed, Lord Bledisloe received a warm welcome on his return from New Zealand. Lord Hastings and Colonel Pratt spoke as Norfolk landowners, the latter referring to the function of the landowner as having to farm what no one else would, in his case three farms out of fourteen. The former spoke as a member of a family who had owned and occupied his present land for seven centuries. He did not complain that recent legislation had been all in favour of the land rather than the landowner; indeed his rents had now recovered to their pre-war figure; but, for the sake of the land and not of the landowner, he did believe that the landowner had a part to play, as a leader and social force, and could play, provided he were left with the means of stocking his land and maintaining its fertility.

The remainder of this, the first session, was occupied by two papers. Dr. Carslaw showed how the new agricultural situation had been met on the farms of the Eastern Counties by an increase both in livestock and in cash crops, with a corresponding increase in purchase of feeding stuffs; also by better rationing of food to stock, and by greater output per unit of labour. Mr. Menzies Kitchin criticized the economics of land settlement, and suggested that if, for reasons other than economic, land settlement is considered desirable, the mixed family farm of 30 to 50 acres would prove the most advantageous. He quoted the astounding forecast that between 1956 and 1976 our population would decrease by thirteen millions.

The means of meeting the new situation was again the underlying thought in Friday morning's session. Mr. C. T. Joice, whose farms were passed through during Saturday's excursion, led off with an address on "Vegetable Growing on a Large Scale." Starting with the Norfolk 4-course rotation as a basis and an abundance of livestock, he had introduced peas, cabbages, sprouts, savoys, parsnips and carrots as crops to supply an all-the-year-round market. Each of these was a dual-purpose crop. For example, the pea straw was eaten by sheep, and all the other crops could be fed to livestock when the vegetable market was unfavourable. It was upon this he considered that success depended.

Another aspect of the same subject was dealt with by Mr. W. B. Adam in a paper on "The Growth of Vegetables for Canning." He pointed out that the climate of Britain was admirably suited to canning, and that the rapid growth of the industry was giving

increased employment. Peas, runner beans, carrots, beets, celery and spinach could all be canned profitably, but asparagus was too costly to cultivate in this country. From the canner's point of view, soil was less important than variety and time of picking, the optimum time of picking peas, for example, being a few days before the abrupt alteration in composition that accompanied the ripening of each variety. This indicated the type of problem that was being studied at the Campden Research Station.

Mr. R. T. Proctor followed with a paper on "The Utilization of Power in General Farming." Power, he described as forced on the farmer by economic conditions, but there were limits to its economic use. For example, where costs had been exactly worked out, planting by hand had been found to be as cheap as planting by machine. This conclusion was supported by subsequent speakers; indeed there seemed to be a reaction from the excessive mechanization advocated in recent years. An interesting example of the use of power was seen during the Saturday's excursion to Messrs. Parker and Proctor's farms at Southacre. Here British Crop Dryers, Ltd. have established a lucerne meal factory, and 2,000 acres are under lucerne. The farms are on the border of the Breckland, but by ploughing 12 or 14 inches deep (which prevents "blowing") and liberal manuring, land which would otherwise be partly derelict has been brought into a state of fertility. Three or usually four cuts of lucerne are obtained, and during the growing season of five months, 120 men are employed in farms and factory, against six men previously on the farms. With the help of portable electric lighting, the work of cutting, carting and drying proceeds night and day. The value of the lucerne meal is held to depend largely on its carotene content, a view justified by the results of feeding it to the cows, bullocks and sows kept on the farms.

Mr. Proctor's paper was followed by a paper by Mr. J. C. Wallace on "Recent Progress in Potato Cultivation in the Eastern Counties." Among the many changes since the war, Mr. Wallace referred to the deeper cultivation for the potato crop, its more frequent occurrence in the rotation, the erection of chitting houses on almost every farm and small holding, the planting of the sprouted potatoes by hand, the use of immature seed which was less likely to be infected with virus and had made Scotch seed less often necessary, the general practice of dry dusting against blight, and the increased yield produced by a higher proportion of potash and nitrogen and lower proportion of phosphoric acid in the manure. The use of potato diggers had not increased; 90 per cent. of the farmers preferred the potato plough for main crop varieties.

On the Thursday afternoon, the Section had visited the Norfolk Agricultural Station at Sprowston, and under the guidance of Mr. F. Rayns, the Director, and the Chairman and members of the Committee and Staff, had inspected the field investigations on problems of sugar beet cultivation. It was therefore fitting that Monday's discussion on Sugar Beet Problems should be opened by Mr. Rayns. He gave convincing evidence of the advantages derived from sugar beet growing in Norfolk, a county which now grew a quarter of Great Britain's crop. These advantages included a fuller and more profitable utilization of the land, as well as more employment during the season, as borne out by the statistics of unemployment relief. Great Britain possessed, he considered, a better climate than any Continental country for sugar beet production, owing to its longer growing season.

Dr. E. M. Crowther dealt with the poor response of sugar beet to chemical manures, even when the land was acid-free, the first necessity of successful culture. It seemed probable that the crop obtained its nutrients from the deeper layers of the soil, and previous cultivations for the crop should be such as to enrich these layers. Mr. H. H. Stirrup described the eight diseases to which the crop was subject, and in most cases the remedy. One of these, "heart and dry rot," was due to deficiency of available boron, and the Section had already seen at Sprowston the remedial effect of applications of borax in inhibiting this disease. Similarly, one of the several varieties of virus disease was prevalent when the soil was deficient in manganese.

The sugar factory point of view was dealt with by Mr. T. G. Fowler. It rested with the factory, he said, to supply seed of the varieties suitable to the soil and climate, and to advise the growers as to the means of securing the highest yields and the right conditions of delivery to the factory, with a view to securing increasing returns as State assistance declined. Lastly, Dr. W. L. Davies described the causes that led to beet taint in milk. It appeared that a considerable amount of trimethylamine was produced by the metabolism of betaine in the ruminant, and that to avoid a fishy taint being thus imparted to the milk, beet pulp should be fed to cows immediately *after* milking, i.e. as far off the next milking as possible. A lively discussion followed the papers; indeed one of the most satisfactory features of the Norwich meeting was the excellence of the discussions at the end of each session.

Monday afternoon was occupied by a joint discussion with the Forestry Sub-section, which, while largely concerned with the afforestation of the Breckland area of Norfolk, yielded some useful

information for owners of estates elsewhere containing comparatively small areas of woodland. Mr. W. E. Hiley pointed out that the inability to market woodland products was most often the cause of neglected woodlands. Co-operation between estates was essential for profitable marketing, and this was now made possible by the Home Grown Timber Marketing Association, which could at once bring into touch the timber and other woodland products of its members with the demand that existed. The National Home Grown Timber Council, set up by the Forestry Commission, was undertaking investigation with the same object in view.

At the concluding session, Dr. J. Hammond, speaking on "The Quality Problem in relation to Meat Production," defined quality as that which the consumer liked best, and what the consumer now liked best was smaller joints, leaner meat, and more tender meat. As long as subsidies were given on weight and not on a quality basis, farmers would buy and breed for the heaviest carcases, and thus spoil the market for English meat. In reply to Prof. Watson, who agreed on the desirability, but questioned the practicability of subsidizing quality, Dr. Hammond replied that it could be done through packing houses attached to slaughter houses, or by basing the subsidy on the price fetched and not on weight only. He thought that the success of New Zealand in supplying the quality required was largely due to the high protein feed, arising from late weaning, grass feeding, and abundant skim milk from the creameries.

Dr. C. Crowther discussed "The Protein Requirement of the Pig." He compared in detail the results of his own experiments with those of other authorities, both for sows before weaning and for pigs up to 90 kg., and gave examples of the rations he would recommend. In answer to questions, he agreed that the good results obtained in Scandinavia and New Zealand by the use of skim milk might be partly due to the abundance of vitamins, as also on Messrs. Parker and Proctor's farms by the use of lucerne meal, but was satisfied that where pigs had plenty of green grass, as in his case, there was no lack in this respect. Capt. Golding next described experiments which showed that a deficiency of vitamin A in an otherwise suitable diet might be the cause of serious losses in young pigs. Continued use, however, of vitamin A concentrate (or cod liver oil) did not appear to be necessary. Dr. H. H. Green, who spoke of anaemia in young pigs before weaning, ascribed the losses thus caused to deficiency of iron in the mother's milk, often due to a genetic factor in the sow. This could be remedied by feeding with fresh grass or by adding a dose of sulphate of iron

to the rations, provided there was a trace of copper also present, which was almost always the case.

All who took part in the proceedings of the Section will wish to congratulate their local secretary, Mr. F. Rayns, on the New Year honour (O.B.E.) which has since been conferred upon him.

T. S. DYMOND.

THE AGRICULTURAL EDUCATION AND RESEARCH EXHIBIT AT THE ROYAL SHOW, NEWCASTLE-UPON-TYNE, 1935

An exhibit covering an area of 120 by 130 feet, of which 80 by 130 feet was under cover, was designed to illustrate the application of modern methods of those particular branches of agriculture and horticulture on which educational and investigational work in the north has been concentrated. The illustrations were as self-explanatory as possible, and a serious effort was made to get rid of any tendency towards a "museum" type of exhibit. Every centre of Agricultural Education and Research in the Northern Province was represented, and the success was due in a large measure to the whole-hearted and generous support, financial and otherwise, given by the four County Councils of Cumberland, Durham, Northumberland and Westmorland.

Education.—The centre-piece of the whole exhibit was a flood-lit panel illustrating by means of photographs, maps and descriptive cards (1) the Provincial area, and the various sources of advice to farmers and gardeners; (2) the education of the modern young farmer; and (3) recent modifications and developments in farm practice that have made educational work so essential.

Horticulture.—The general plan permitted a portion of the horticulture section to adorn the main approach to the exhibit, and in addition to the purely ornamental part, the outside beds illustrated methods of fruit-growing in the North. Specimens of fruit trees and bush fruits suitable for northern conditions were on view, and considerable interest was shown in two specimens of apple trees on which "porcupine grafting" had been carried out. Two plots of potatoes illustrated the degeneration of potato stocks, and the diseases responsible for such degeneration, while horticulturalists who find increasing difficulty in obtaining supplies of farmyard manure, found the exhibit dealing with the production of synthetic manure of great value to them.

The inside bench exhibit dealt mainly with the production of soft fruits and early vegetable crops, but two other features attracted much attention; (1) a series of photographs showing the results obtained in planting up waste slag heaps in County Durham; and (2) diseases of fine turf, e.g. bowling and golf greens. This was a new feature of Royal Shows, and Dr. F. T. Bennett's work in this connection has received much international appreciation, although it is under two years since the life history and methods and control of these diseases were worked out.

Grass Land.—This section was mainly a bench exhibit, but a row of specimen turves from the more famous plots on Tree Field, Cockle Park, were laid in the open. These turves, each 10 feet by 5 feet, were in contrast to the usual method of showing small turves in boxes, and proved most effective in enabling the farmer to form a better idea of the grazing value of the pasture.

A considerable number of investigations have been made, and are still being carried out, by Mr. B. Thomas on different aspects of grass land husbandry, and the results of a number of these investigations were shown. As might be expected, Cockle Park provides a series of long continued manurial experiments, the real value of which has never been fully appreciated. It was probably unique to find at one experimental station, at one time, three different systems of utilizing grass, namely: grazing by sheep alone, grazing by a mixed stock of sheep and cattle, and by rotational grazing. Certain investigations are designed to correlate the productivity, in terms of live weight increase of the animals used, with the chemical analysis of the herbage at different seasons of the year, and with the annual output of dry matter and the proportions of its more important constituents.

The composition and feeding value of the herbage of upland sheep grazings has not yet received the attention it deserves from research workers, but hill farmers have long upheld the value of common heather, draw-moss (cotton sedge) and stool bent, and chemical analysis throws interesting light on these practical observations, and it is possible that the results displayed in this section may have to be correlated later with the incidence of hill sheep diseases on certain grazing areas.

Crop Husbandry.—This section was largely restricted to two locally important poincs in connection with arable crops, namely, the effects on crops of lime deficiency in arable soils, and the general importance of the oat crop as the most extensively grown cereal. So far as lime deficiency was concerned, the exhibit took the form of samples of all the important arable crops growing in pots or

boxes, where lime deficient soils were used, alongside specimens grown in the same soil to which had been added lime in varying quantities. Exactly the same seed was used in comparable specimens, and the resultant plants were most striking in some cases.

The oat crop was dealt with through all stages from sowing to utilization; the effects of dates of sowing, the necessity for grading seed before sowing, and the importance of the control of weeds and diseases were all dealt with. External infections by fungus diseases may be largely controlled by treating the seed, before sowing, with mercurial compounds, but the incidence of *Fusarium* diseases is not widely appreciated, although the effects are estimated to reduce British crops by 25 to 30 per cent. Investigations on these diseases have been pursued by Dr. Bennett, who exhibited specimens and cultures of the fungus diseases. The control of internal infection of the seed by dry heating has not proved to be of practical utility, and methods of biological control seem to offer the best means of dealing with *Fusarium* diseases.

Poultry.—The section devoted to poultry husbandry was the subject of much favourable comment from visitors, not only because of the effective layout, but also because of its material value. The central feature was a statistical picture of the industry and of its economic experiences in recent years. Financial results on a number of farms over a three-year period were illustrated in such a way that it was possible to point out the particular farm where results had been consistently good, or bad, or where variable results indicated that attention should be directed to finding out how the divergence arose. Some of the causes of poor results were illustrated pictorially, and the importance of healthy stock, the necessity for good management, and the general principles upon which to manage a successful poultry farm were all illustrated. The more important diseases and their treatment or control formed the subject of one of the sub-sections.

Dairying.—A small demonstration dairy was provided, and a programme of demonstrations in the making of ice cream, soft cheeses and butter was carried out, special attention being directed to the incidence of faults in butter making, and how to obviate or correct these. The accommodation provided for over fifty visitors was always fully occupied during these demonstrations. Much attention was taken in a display refrigerator cabinet; in a display of the products of county dairy schools and in the section devoted to plants and equipment capable of producing faults and taints in dairy products.

One part of the exhibit, arranged in collaboration with, and financed by, the Milk Marketing Board, aroused a great deal of interest and discussion. The whole section was intended to portray methods suitable for the production of milk of the standard necessary to enable the herd owner to qualify for enrolment in the Accredited Producers' Roll. The equipment was not too elaborate, but such as would be suitable for a herd of about thirty cows. A room was equipped with models illustrating how alterations might be made to existing buildings to bring them up to standard in the matter of ventilation, lighting, up-to-date standings, and the provision of modern forms of equipment. The remainder of the section was in full-size layout, showing the provision of pressure boiler installation; washing-up room; a dairy; small room for milk receiving container and weighing apparatus; and a room fitted with a wash-hand basin, and provision for milkers' overalls. The byre was most effective in that it illustrated three features in full size; the first was an out-of-date type of stall with wooden fittings, overhead hay rack, cobbled floor with long standing, and inefficient lighting and cleaning equipment. The second showed how the same stall could be converted by the farmer, with his own labour, into a type that has proved to be very effective and labour-saving. The third was the provision of a modern tubular fitted stall with head feeding passage and continuous feeding trough, along with the type of electric light fittings suitable for modern byres.

Livestock.—The livestock consisted of about thirty sheep, twelve cattle and four pigs, the pens being arranged so that it was possible to inspect the animals without actually entering the Pavilion. It proved an attraction to visitors at all times, and was well worthy of the extra work involved in looking after the stock during the Show.

Sheep.—The intention was to illustrate how the hill breeds formed the foundation of lowland flocks. Cheviot and Blackface ewes, with lambs by Border Leicester rams, and Swalesale ewes, with lambs by Wensleydale rams, occupied the first pens. Ewes of these crosses with lambs by suitable Down breeds of rams completed the picture of commercial flocks of the district. Running parallel with the pens was a bench exhibit showing statistical information as to the sheep population of the area, special attention being directed to the place occupied by the half-bred ewe. Turves showing the types of grazing commonly associated with the hill and lowland flocks gave the visitor an idea as to the types of pasture upon which the different breeds were kept.

The incidence of sheep diseases, to which so much attention has been directed in recent years, carried the story a stage further, and

this section was confined to seven outstanding diseases of Northern sheep, while four pens of sheep suffering from scrapie, pining, and blood-rot were on view. On benches were specimens and paintings of various diseases with information as to the appropriate preventive and control methods to be used to combat them. In appropriate cases the proper equipment for dosing the animals was displayed, along with charts depicting the results of inoculation experiments.

Cattle.—These pens, each containing two animals, were a great source of interest, illustrating as they did the chief breeds and cross-breeds used for beef production in the area, they were:—

(1) A white Shorthorn cow with calf by Aberdeen-Angus bull.
(2) A pair of 15-months-old stirks by Aberdeen-Angus bull, out of Aberdeen-Angus × Shorthorn cow.
(3) A pair of 15-months-old Aberdeen-Angus × Shorthorn stirks.
(4) A pair of 15-months-old stirks by Aberdeen-Angus bull out of blue-grey (Shorthorn × Galloway) cow.
(5) A pair of two-year-old blue-grey (Shorthorn × Galloway) steers.
(6) A pair of Shorthorn × West Highland steers, three years old.

In addition there was a comprehensive and valuable exhibit of paintings, prints, and photographs giving the history of the Aberdeen-Angus and Shorthorn breeds.

Pigs.—The inception of the Pigs and Bacon Marketing Boards brought the question of the diversity of breeds and types of pigs in this country very much to the front, and the object of this section of the exhibit was to illustrate how the home bacon trade can be supported if the pig breeder produces the type of pig required by the bacon factory. Four pens of live pigs were shown to illustrate certain features, namely:—

(1) A pig of suitable type and correct weight for Class I
(2) A pig of correct weight but of unsuitable type.
(3) A pig of suitable type but over weight.
(4) A pig of suitable type but under weight.

Carcases corresponding to the live pigs were shown to illustrate the points regarded as important by the bacon factories, or the features that would result in a carcase being placed in a lower grade. The bench exhibit dealt with breeding, feeding and management problems, and a display of hams illustrated the bad effects of unbalanced or unsuitable rations resulting in taints or faults in the bacon.

D. T. ADAM.

THE THIRD INTERNATIONAL CONGRESS OF SOIL SCIENCE, OXFORD, 1935

The International Society of Soil Science held its first two Congresses in U.S.A. in 1927 and in U.S.S.R. in 1930. At both of these the outstanding theme was the genetic and regional approach to soil classification, which was most admirably illustrated by the elaborate trans-continental tours which followed these Congresses. With the re-orientation of outlook and the modest resources available after the economic crisis, it was perhaps particularly appropriate that the Third Congress should be held under the entirely different conditions of a small and highly cultivated old country in which a wide variety of soil conditions calls for detailed local surveys and field experimentation. The Congress demonstrated the dangers of too restricted and parochial an attitude in several branches of soil science, and showed that there was little prospect of solving many pressing practical problems until the more direct attack was balanced by long-range investigations on fundamental problems.

The Third International Congress of Soil Science was held at Oxford, from 30th July to 7th August, 1935, under the Presidentship of Sir John Russell, and was attended by over 400 delegates from more than 50 countries. About 150 delegates subsequently took part in a 16-day tour of Great Britain. It was generally agreed that the charm of Oxford, the beauty of the British country-side, and the interest of the discussions, both in Conference rooms and around soil pits, combined to maintain and even to enhance the high standards of the earlier Congresses and Tours. Some useful innovations were introduced. The British Organizing Committees had produced in advance volumes containing the papers to be read at the morning Plenary Sessions and the afternoon meetings of the six separate Commissions, and a guide-book giving full descriptions and analytical data for most of the profiles to be inspected on the tour. An attempt was made even to limit the length of speeches by means of improvised sets of traffic signal lights.

Some of the outstanding subjects at discussions were: a method due to Schofield for relating the various empirical soil-water constants, the structure of the clay minerals in the light of X-ray and physico-chemical work, surveys for land utilization, and occasional conflicts between morphological and chemical methods of soil characterization. In the Commission on Soil Fertility, Professor E. A. Mitscherlich presented the results of a co-operative study of methods for estimating fertilizer requirements. This revealed wide

discrepancies between methods which are enthusiastically advocated in some quarters and led to the conclusion that co-ordinated schemes of accurate field trials were urgently needed to check these methods and to discover their ranges of application.

The principal centres visited on the tour were, Harper Adams Agricultural College, Bangor, Aberdeen, Edinburgh, Newcastle, East Yorkshire and Cambridge. In addition, there were visits to Rothamsted, Jealott's Hill and Billingham, Government Banquets in Oxford and Edinburgh, and Civic Receptions in Aberdeen, Edinburgh and York.

E. M. CROWTHER.

THE SIXTH INTERNATIONAL CONGRESS FOR SCIENTIFIC MANAGEMENT, LONDON, 1935

The Sixth International Congress for Scientific Management met in London in July, 1935, and it is not without significance that for the first time a separate section was devoted to agriculture. The theme of this section was "Standardization as a factor in Agricultural Development, including Standardization of Equipment, Methods and Produce," and the particular subjects chosen for discussion were: (*a*) mechanization on the farm; (*b*) the use of accounts in farm management; (*c*) the preparation of produce for market and (*d*) specialized *versus* mixed farming. Altogether, thirty-four papers were contributed, including four from this country, and the published reports extend to 176 large printed pages.

Has all this effort justified itself? So far as the congress itself is concerned, it must be admitted that the attendances were very meagre and there was a notable lack of attendance on the part of those who are wont to be seen at agricultural conferences of one kind or another. Had the Congress been arranged by, say, the Ministry of Agriculture and been devoted entirely to scientific management in agriculture it is safe to say that it would have been much more widely supported.

On the other hand, it is perhaps an indication of the growing recognition of Agriculture as one of the great basic industries that it should have received a separate section in this Congress. Whether it is called "scientific" or "practical," there can be no doubt that there is scope for *better* management in agriculture and it would indeed have been rather strange if a Congress on management problems had *not* included what readers of this *Journal* consider to be the most important industry of all.

The papers, together with the discussions, are of course available to any who care to read them* and it is always a difficult matter to assess the extent to which such reports are actually of value to the general reader. Force of circumstances compelled the writer to read all the papers at least twice (foreign languages excepted) and the general conclusion must be that they form a notable contribution to agricultural literature. At any rate, it is good for all of us to be reminded that almost every agricultural problem has its international aspects.

It was unfortunate that one of the principal agricultural speakers at the Congress should have given such an excellent demonstration of *un*-scientific management by missing his train and holding up the proceedings for a full half-hour of valuable time!

JAMES WYLLIE.

THE AGRICULTURAL ORGANIZERS' CONFERENCE, CAMBRIDGE, 1935

The Seventh Conference of Agricultural Organizers was held in Cambridge from the 25th to 29th June, 1935. Members were accommodated in Emmanuel College and the meetings were held in the School of Agriculture. The comfort of residents during a very trying period of the heat wave was in no small measure due to the arrangements made by the College authorities, the staff of the School of Agriculture and by the Organizing Secretary (Mr. J. L. Whytehead).

The session opened with a paper by Mr. A. W. Street, which commenced by sketching the progress of marketing and distribution reforms up to the present day. The attacks of the opposing schools of thought were dealt with fearlessly and a full discussion of the weaknesses of the schemes, as revealed by these critics, was not shirked. Mr. Street indicated the future development of marketing schemes and pointed out that during their evolution they would inevitably encounter external forces even of international magnitude. The impression left by the paper was that its author embodied that rare product the visionary and the practical man.

Major Garnsey delivered an address on Agricultural Education and traced the growth of this vast organization from its puny infancy, nutured by the "Whisky Money," to its present status in the national economy. An invaluable collection of data was given,

* Published by P. S. King & Son, Great Smith Street, S.W.1.

the whole thesis amounting to a compact history of agricultural education in all its aspects. Future problems were examined and recommendations based on past experience were made, the problem of the Farm Institute receiving special consideration. A plea for a wider cultural outlook in the curriculum was put forward and the difficulties in making this provision were discussed.

Sir Daniel Hall followed with an address supporting the previous speaker's demands and giving the practical details of what he considered to be the ideal scientific training and suggestions as to a means of providing the oft demanded cultural instruction. The former would embrace biology in its real sense, thus leading the student to approach his problems in a truly scientific manner, rather than to be guided by the emotional. It was pointed out that cultural instruction could well take the form of experience in literal and verbal expression, a qualification having a direct commercial value and being possessed by few.

The most interesting point raised in the discussion of the joint papers was that of the respective positions of practical and theoretical training. It was pointed out that many a promising recruit had been lost to the industry by an employer who adopted the methods of the lion tamer rather than those of the skilled horse-breaker.

To those who lacked experience of the workings and difficulties of the Milk Marketing Scheme, the paper by Mr. Llefelys Davies provided complete enlightenment. The figures given by the author left no doubt as to whence the deluge of surplus milk originated. One fact that emerged was that the present scarcity in the market of good dairy cattle was likely to become intensified.

On the second morning of the Conference, papers were read on "Bacon Marketing" and "The Reorganization of the Marketing of Pigs." Mr. G. F. Spear dealt with the former topic and Mr. J. A. Fox with the latter. The speakers traced the progress of the schemes, commencing with the chaotic conditions which necessitated their inception. They described their early embarassments and proceeded to examine future problems. In both cases the facts, as stated, were a frank declaration of the difficulties surrounding attempts at organized marketing. They called for sympathy and constructive criticism.

For those members who were becoming overwhelmed by the host of economic problems presented to them, the paper by Dr. John Hammond gave a refreshing respite. "Breeding for Bacon," the title of the paper, is a problem which is being attacked with vigour at Cambridge by Dr. Hammond and the staff of the School of Agriculture. The combined efforts of the geneticist, the physiologist

and the statistician were embodied in the paper and the information gained so far was not only valuable in itself, but augered well for the future.

Mr. Blundell's paper on "Eggs and Poultry Marketing" revealed figures as to consumption which contrasted strangely with those for other commodities. In his opinion there was still room for increased output of British eggs under a proper control. One gained the impression that this scheme had more to fear from a diversity of vested interests than any of those affecting other departments of the farm.

Mr. Seabrook gave the paper which concluded the Conference and dealt with "Fruit Marketing." The "completeness" of the proposed scheme was blamed as the possible cause of its rejection. The value of the National Mark was stressed as was also the need for timely advertising. The "small man" appears to present a special problem in the case of fruit marketing, lack of such facilities as cold storage being one of his chief handicaps. It is evident that there is a need for trained packers and other skilled workers.

A very interesting afternoon was spent at the University farm in Dr. Hammond's department. Members were impressed with the fact that the bulk of the research carried out at these centres is devoted to investigating problems which have arisen from recent agricultural reorganization.

On the evening of Friday, 28th June, a dinner was held at which the Minister presided. The proceedings were enlivened by speeches, some of a serious and informative nature and others in the lighter vein. A very pleasant evening was brought to a close with a reception by the Minister in the picture gallery.

YOUNG FARMERS' CLUBS EVENTS

THE ROYAL SHOW, 1935.

International Stock Judging Contest.—This attracted a record entry of five teams—U.S.A. (after an absence of two years), Scotland, a newcomer warmly welcomed, Northern Ireland, Wales and England.

The competition was very keenly contested and from the start, up to the very end, the issue was in doubt. There were only 52 marks between the first four teams.

The English team was the only one in which girls were included, and one of these, Miss Peggy Busby, came 3rd in the individual

scores. The highest individual scorer was A. Biggar, of the Scottish team, with J. Brown, from Northern Ireland, second.

Six rings of cattle were judged, and reasons given orally on three rings.

The first ring to be judged was the Dairy Shorthorns and here England obtained full marks for placing. In the rings for Friesians (two classes) competitors differed considerably in their placings. Northern Ireland and Scotland both excelled in the Ayrshire class. In the afternoon, England and Scotland both obtained full marks for placing the Guernseys. In the last class—Jerseys—most of the competitors obtained good marks.

Excellent reason-giving on the part of the English team was the chief factor in their success.

The National Federation has to record once more its debt to the Royal Agricultural Society of England for the facilities granted to hold this contest. The President of the Society, H.R.H. the Duke of Kent, conferred an honour on the Federation by presenting the Gold Cup, Medals and Certificates of Merit.

England has now won seven times, U.S.A. six times, and Northern Ireland once.

SUMMARY OF RESULTS.

Order of Teams.	Pts	Highest Individual Scorers	Pts.
1. England	1286	1 A. Biggar (Scotland)	460
2. Scotland	1268	2 J. Brown (N. Ireland)	458
3. N. Ireland	1248	3. Miss B. Busby (England)	445
4. U S.A.	1234	4 J Thompson (England)	441
5 Wales	1074	5 R Putman (U S.A.)	414

Y.F.C. Stock Show.—This display of Club members' stock, included in the R.A.S.E. catalogue for the first time, was an outstanding success. Entries were confined to the two counties of Northumberland and Durham.

There were over 140 animals shown in eight classes for Dairy and Beef cattle.

The quality of the Stock and the condition in which it was exhibited have undoubtedly added prestige to the Y.F.C. Movement. The two judges were enthusiastic on the excellence of the animals, and from the remarks of the spectators at the ring side, which was packed, there is no doubt that farmers from all over the country shared their opinion. The Young Farmers were honoured by the presence of the Duke of Kent, who was keenly interested.

THE LONDON DAIRY SHOW, 1935.

Dairy Cow Judging Competition.—Twenty-three county teams entered. Restriction of the space available for judging rings

necessitated the reduction of the strength of the teams from three to two members. The contest consisted of two eliminating and one final test, and twelve rings of four animals were examined. The eight teams left in the final were given a task requiring considerable ability.

Durham County team won the contest, repeating their victory of 1933. They were a consistent and level pair and came 2nd and 3rd in the individual list.

Surrey, the second team, occupied this position last year. W. R. Thomas, of Surrey, headed the individual score, making the third occasion on which a member of this family has achieved the honour.

On the three days the percentages were 74, 74, 81, with an average over all of 76·3, i.e., nearly 46 marks out of 60. The official judges were Captain W. Burrell, Messrs. J. H. Faulder, R. W. Hobbs, H. G. Robinson and Professor J. A. S. Watson. Most interesting and helpful discourses were given by them at the close of the contest. These gentlemen merit the thanks of all competing members for the time and attention they gave to this competition.

Lord Rowallan, this year's President of British Dairy Farmers' Association, presented the Cup and Medals, and made an excellent speech on the value of Young Farmers' Clubs.

SUMMARY OF RESULTS OF FINAL CONTEST.

Teams.	Max 720 Pts.	Individual Competitors	Max. 360 Pts.
1. Durham	596	1. W. R Thomas (Surrey)	318
2. Surrey	586	2. J. C. Atkinson (Durham) ..	302
3. Northumberland	568	3. T. C. Vickers (Durham)	294
4. Bucks	552	4. E. Christopher (Northumberland)	291
5. Hants.	541	5 G Malcom (Hants.)	285
6. W. Sussex ..	524	6 A. J Peverill (Bucks.)	278

Poultry Judging Competition.—Seven Clubs entered teams, and four breeds of poultry were judged. The contest was keen and called for all the skill the competitors possessed. Reason giving was of good standard, but several members could not be heard well.

Chiddingfold won the Dr. Bailey Cup for the second year in succession. They were followed by Farrington Gurney, who, in their first attempt, put up a very creditable performance.

The individual champion was Anthony Munlay, aged 13, from Sevenoaks Weald, Kent. He is probably the youngest and smallest member ever to win the British Dairy Farmers' Association Silver Medal.

The Judges were Messrs. H. Howes and A. F. Tomey.

An extract from a report by one of them reads . . . "I could not help noticing the competitors' keenness and their eagerness to do the job really well. . . . It was a real pleasure to watch them handling the birds—they have evidently received good training in this very important phase of judging."

SUMMARY OF RESULTS.

	Teams.	Pts		Individual Competitors	Pts.
1.	Chiddingfold ..	817	1	A Munlay (Sevenoaks Weald) ..	287
2.	Farrington Gurney	754	2	Enid Carn (Chiddingfold) ..	281
3	Ringmer	706	3	W G. Weller (Chiddingfold) ..	270
4.	Croft	702	4	Helen Carn (Chiddingfold) ..	266
5.	Sevenoaks Weald	693	5	Caroline Golledge (Farr Gurney)	262
6.	Hunwick	670	6	Brian Green (Farr Gurney) ..	257
7.	Walthamstow Hall	583			

THE LORD MAYOR'S SHOW, 1935.

The National Federation of Young Farmers' Club had the honour to be invited to take part in the procession of the Lord Mayor of London. The exhibit consisted of a decorated lorry, depicting a farm scene, with a dairy, calves, sheep, pigs, poultry and pigeons; also a shepherd and his dog. Each section was covered with a thatched roof. Preceding and following the lorry were Club members attired in white coats and green berets, representing various Club activities. The "Club Leader" and the "Club Secretary," both mounted, had positions at front and rear of the procession. Altogether 48 members from ten counties participated. The exhibit attracted a good deal of attention and received favourable comment from the Press and other sources.

SMITHFIELD CLUB, 1935.

Beef Judging Competition.—Instituted in 1931, this competition has shown a steady increase of interest each year.

Sixteen teams from Young Farmers' Clubs and kindred organizations took part this year, and generally their work was marked by confident approach and a display of skill which told of careful training.

Each team had to judge four rings of cattle of different breeds.

Three Silver Cups offered to the best team were won by a team representing Cornwall, with a total of 1,069 marks out of a possible 1,440. A team from Catterick Young Farmers' Club was reserve, with 1,035 marks, and other teams in order of merit were County of Devon 1,033; Chiddingfold Young Farmers' Club 1,027; Durham Federation of Young Farmers' Club's 1,025; and Northallerton and Bedale Young Farmers' Clubs 1,024.

A Gold Medal for the best individual performance was awarded to M. Kingdon, of Cornwall, who received 377 marks. T. E. Ramshay, of the Catterick team, came second and received a Silver Medal, while Bronze Medals were presented to J. Thompson, of the Durham team, and E. Minty of the Sodbury team (Gloucester).

ROTHAMSTED CONFERENCES, 1935

Three Conferences took place at Rothamsted in 1935. Two were concerned with agricultural subjects; the other dealt with apicultural questions, and enabled a large number of practical bee-keepers to get in touch with the research workers who are studying some of their most pressing problems.

In the agricultural field, pigs and barley were the two subjects chosen. On 6th March there was a well attended meeting to discuss "The Production of Pigs for Bacon."* The proceedings were opened by papers from practical breeders and feeders, a physiologist, and the manager of a bacon factory. A lively discussion ensued in which the divergent views of pig producers and curers were frequently in evidence. Two points raised considerable discussion, one was purely a technical matter, the other involved the terms of the contract then in force.

Should rapidly growing pigs receive a ration somewhat higher in protein than the standard recommendation? Some speakers claimed that to secure a lean carcase with a thick streak, composed of muscle as distinct from fat, a generous supply of protein was desirable. From various quarters, evidence came to hand that there was something in this view. The case seemed to be tied up with the possibility of a cheap source of animal protein.

The nature of the belly measurements as stipulated in the contract came in for much criticism. Mr. H. R. Davidson, in a paper entitled, "Does it pay to produce Grade A pigs?" showed that the English standard for belly measurement was more severe than the Danish, for our Grade A pigs had to be at least 1·5 inch thick in the belly, whereas the corresponding Danish Grade I pigs had a belly measurement of only 1·3 inch. We had the very difficult problem of producing in the one animal a thick belly with thin back fat. Most speakers supported Mr. Davidson's view and some suggested that there should be two contracts, one for the Midland

* Rothamsted Conferences, XIX. "The Production of Pigs for Bacon." Price 1s. 6d.

trade, where a thick streak was essential, another for the Wiltshire trade, where thin back fat was important.

On 6th November, a second conference on Malting Barley was held on the lines found so successful in 1934. The number of samples sent in for grading and display was 270, an increase of 70 on the previous year. A feature of the Conference was the demonstration of the samples by the Valuation Committee, whose members answered the questions of growers who were interested in the grading of their barleys. An examination of the grading results in the light of the agricultural treatment of the samples indicated that autumn sowing, or very early spring sowing, tended to give samples better than average. In the dry season of 1935, the barley soils on the heavy side of medium did better than those in the very light class. A feature of the returns was the predominance of the Spratt-Archer variety in Norfolk, and the large amount of Plumage-Archer grown elsewhere. The conference was a great success, and served to bring growers and buyers into discussion in an atmosphere distinctly less commercial than that of the Corn Exchange.

On 27th April, the subject was "The Cause and Control of Swarming in Bees."* Modern bee-keeping has made the control of swarming necessary and to some extent possible. Work has been in progress at Rothamsted for some years to ascertain some of the principles underlying the methods of swarm control which have proved successful. The first four speakers at this conference are adherents of the Brood Food Theory of Gerstung and Bullamore. Briefly, it is supposed that the preparation of queen cells, which preceded the issue of the swarm, is due to the presence in the hive of a surplus of nurse bees over the requirements of the brood. This leads to the feeding of some of the female larvæ on "royal jelly" after the age when they would normally be weaned to other food in order to arrest the development of the sexual organs. The larvæ so favoured become queens. The provision of other outlets for the bees' activity, and the removal of nurse bees from the vicinity of the brood, are potent factors in the control of swarming.

Miss Betts (Editor of the *Bee World*) summarized the history of theories and systems of swarm control. Brother Adam (of the Buckfast Abbey bee farms) went into the Gerstung theory in greater detail, and described the control measures practised at Buckfast. Mr. D. Morland discussed the bearing of the work of Rösch on the division of labour in the hive, with promotion according to age, and some of the experiments carried out at Rothamsted which bear on

* Rothamsted Conferences, XX. Price 1s. 6d.

this. Mr. Snelgrove described the method which bears his name, which may be said to be derived from that of Demaree. Mr. Pryor led a discussion on the Demaree system which in its many forms is perhaps the most widely used, not only in America, its country of origin, but also over here. Mr. Clay gave an account of the system used by Mr. Peck of the Chivers fruit farms. Finally Mr. Hamilton, of Leeds, declared his entire disbelief in the brood food theory. In his view the cause of swarming was a state of fear, experienced by the worker bees brought about by some change of odour of the queen.

THE OXFORD CONFERENCE ON FARM MECHANIZATION, 1936

The interest and attention being given at the present time to the application of mechanical power and other labour-saving devices to agriculture was amply demonstrated by the attendance of some two hundred agriculturists at a conference on "Mechanization in Mixed Farming," which took place in Rhodes House, Oxford, from 7th till 10th January, under the joint auspices of the School of Rural Economy, the Agricultural Economics Research Institute, and the Institute for Research in Agricultural Engineering, of the University of Oxford.

Mr. A. Bridges, in a paper on "Specialized *versus* Mixed Farming," said that the mixed arable farmer of to-day with his eggs in a great variety of baskets, some of them not very full, was beginning to wonder if there was need for all the complexities of his system. His future lay in a less diversified system with the idea of specialization in labour and simplification of mechanized agencies as they are proved economical.

Dr. H. G. Saunders declared that the well-established principles underlying rotations were fully capable of taking mechanization in their stride and farmers would not go far wrong if they based their cropping sequence on them. Root crops could be mechanized and there was a lot to be said for the Norfolk four-course rotation, though not in its entirety. Where a contract for sugar beet could be obtained the rotation—sugar beet—barley—seeds or peas—wheat was a good one.

He thought, however, that since cereal crops were more easily mechanized, we would settle down to six-course rotations, with recuperative crops every third year, the others being white straw crops.

Mr. Dunstan Skilbeck, of the School of Rural Economy, spoke of the way in which machinery had been applied on the St. John's College Farm, which when it fell in to hand, was suffering from the effects of depression. Mechanized grain-growing was adopted in the first instance and though returns were satisfactory, intensification had been carried out, with improved economic returns consistent with increased employment. Mr. Skilbeck argued for the development of the new arable farm, designed on the principle of one man, one job; where labour, properly qualified in its work, is properly equipped for its work, and machinery is wisely but not fanatically used to bring living land back into fertility.

Mr. E. D. Walton, describing his experiences with a tractor on his own farm of about 190 acres, situated near Diss, Norfolk, remarked that since wages were 100 per cent. higher and prices of farm produce only 20 per cent. higher than pre-war, the tractor was the only means of bridging this gulf, and therefore he considered that the small farmer must adapt his present system to the tractor. He should not contemplate revolutionary changes. By using the tractor, one man could enormously increase his output, as there were fewer turnings with the tractor than with horses; while speed to the tractor man was a joy, to the horseman, it was an effort. Further, no large capital expenditure was required as many horse implements could be adapted for tractor use.

Mr. J. E. Newman discussed the equipment of the row-crop cultivator, and Mr. Warburton the subject of farm transport.

Mr. W. S. Mansfield, of University Farm, Cambridge, was of the opinion that on the majority of farms the tractor merely supplemented horses. He upheld this by stating that in 1914, when tractors were non-existent in this country, there was one horse for every 13·9 acres of arable land, while in 1935, when thousands of tractors were in use there was one horse for every 16 acres.

This view received support from Mr. W. D. Hollis, of Lickford Estates, Ltd., Stockbridge, Hants., who said that stock can be incorporated in a policy of mechanized farming, with material assistance to the arable land; it was his belief that the future of mechanized farming must be in crop and stock.

Folding systems, grassland improvement, and the use of long leys in mechanized farming were other subjects dealt with. Of particular interest was the account given by Mr. Clyde Higgs, Hatton Rock, Stratford-on-Avon, of his experiences in grass-drying on his own farm. He said that one must always dry the best grass available, for the simple reason that the cost of drying is the same whether

the first product is rich or poor. The aim should be to improve the land for drying, rather than by drying.

He declared that commercial grass-drying for the farmer has arrived and that it represents one of the greatest advances in agriculture for centuries. This year he would cut his feeding bill in half and, in addition, he would employ ten extra men permanently, for with the money saved in purchased goods, he would keep these men employed—when the drier is not working—in hedging, etc., and so improve the productivity of his farm.

In concluding his paper, Mr. Higgs put forward the following more important "Dont's for Driers." Don't try to reclaim your land through the drier; clear the rubbish off first; don't apply all your fertilizers at once; don't omit to fertilize liberally but judicially; don't cut the same fields all the time; don't waste your dried grass when feeding, treat it with the same respect as you do cake.

Other subjects covered were mechanization on medium-sized farms, methods of labour-saving without the use of combines, methods of grain storage on the farm, and the movements of farm prices.

J. B. PATERSON.

OBITUARY

JAMES STANLEY SIMPSON

The Association has suffered a grievous loss by the death of its Treasurer, Mr. J. S. Simpson, at the early age of thirty-seven. He passed away on February 18th, 1936, after an operation for appendicitis, aggravated by a severe cold, which afterwards developed into pneumonia.

Simpson was born in Yorkshire on 17th January, 1899, and was educated at Archbishop Holgate's Grammar School, York. He joined the West Yorkshire Regiment as a private in 1917, saw service in France, received a commission as Second Lieutenant, and was demobilized in 1919. He proceeded to the University of Leeds, and took his B.Sc. in Agriculture. After graduation he was Assistant for Farm Costing Accounting with Dr. Ruston until in 1923 he was appointed Agricultural Costings Officer and Lecturer in Farm Economics at the University of Reading. Later he was made Advisory Economist.

He joined the Association in July, 1923, and in 1925, when it was decided to split the offices of Honorary Secretary and Treasurer, hitherto jointly held, Simpson was elected Honorary Treasurer.

In the same year the University of Reading paid Simpson, a young man of only twenty-seven, the great compliment of entrusting her financial affairs to him, for it was in 1925 that he became Bursar. Dr. W. M. Childs, the first Vice-Chancellor of Reading University, wrote thus to *The Times*:—

"The responsibilities of the young Bursar were arduous and complicated. All the finances of the University, including those of its six Halls of Residence, experimental farm, horticultural station, and other properties, and all the expenditures relating to the maintenance of buildings of all descriptions, came under his immediate supervision. He began quietly and modestly, but he soon impressed those who had opportunities of testing his work by his thoroughness and grasp. He developed an exceptional power of lucid statement in council and committee, and his judgment upon questions of financial policy soon won the respect which it deserved. In everything relating to agricultural finance he was an expert who not only understood his job but loved it."

It might have been expected that Simpson's multifarious duties would have made it impossible for him to continue as Treasurer of the Association, but, fortunately, he was too interested in its work and its personnel to think of resigning. For ten years he watched over the finances of the Association, and it is mainly due to his careful handling that they are to-day in so healthy a condition. As a member of Council his advice and opinion were of the greatest value, and to the Officers of the Association he was a tower of strength whenever difficult and controversial problems cropped up.

During his tenure of office, Simpson never missed a conference, and his cheerful countenance and inevitable pipe seemed to be an essential part of the proceedings. He was an excellent companion, with a keen sense of humour, always looking for the bright side of things. Well able to stick up for his own opinions, as a true Yorkshireman should, he was always ready to see the other fellow's point of view, and he made no enemies. With his passing the Association loses a good friend and helper, whose cheery presence will be greatly missed.

D. H. R.

REVIEWS

The Chemistry of Milk. By W. L. Davies, Ph.D , D Sc., F.I C. **Pp.** xii + 522. (Chapman & Hall.) Price 25s.

The publication of this monograph will be welcomed by teachers and students of dairy chemistry as well as by those engaged in the distributory and manufactory branches of the dairy industry. The author has referred to nearly 1,400 original papers, a large proportion of which are undoubtedly inaccessible except to workers attached to institutes with excellent libraries

The subject matter of the book is divided into five parts, dealing with the composition, constituents, physical chemistry and nutritive value of milk, and the chemistry of milk processing The milk constituents, the factors influencing the composition of milk, the action of milk on metals, the chemical changes which occur during processes such as cheese-making, and development of rancidity or tallowiness in butter are very fully discussed and should have a general appeal. The section on the chemistry of milk-processing is of primary importance to the manufacturer, while an excellent account of our present knowledge of the nutritive value of milk is given The author and subject indices are particularly good

The material is attractively presented, the style being simple and concise The various sections should be easily understood even by those with only a superficial knowledge of chemistry. The paper and binding are good and the print is easily read.

A. L. P.

The Land—Now and To-morrow. By R. G. Stapledon, C B E , M A. **Pp.** xvii + 336, with charts and maps (Faber & Faber) Price 15s

In his latest work Professor Stapledon makes a plea for the better utilization of the land of these islands, with special reference to the grasslands. He produces figures to show the alarmingly rapid rate at which farm land is being swallowed up for housing estates, aerodromes and similar purposes, and considers that in view of the limited amount of good arable land there is an imperative need for the formulation of a long-term policy of grassland development. He claims that modern methods now make the improvement of hill grazing a comparatively simple matter, and he again emphasizes his belief in long leys as opposed to permanent grass.

His philosophical outlook everywhere finds expression. "With regard to the land surface of this country, I think that more weight should be given to its use relative to health, pleasure and mental balance than even for food production" (p. 8). "I repeat that what the nation should demand of its agriculture is flexibility" (p. 14). "I do not believe there is a single issue upon which public money could be spent on a generous scale with greater national advantage than in seeking the means and in enforcing action that would once and for ever ensure that every human being, animal and plant inhabiting this island, breathed only an uncontaminated atmosphere" (p 43)

It is probable that the reader of these paragraphs will have already seen general reviews of Professor Stapledon's book; the author's opinions on Education and Research deserve more than passing attention by members of the Agricultural Education Association (Ch. XXV).

He denounces the standardization of education, the examination system, and the "huge vested interest" that has grown up around it. He "can see no hope of introducing a broader and more varied scheme of education until the examination system is abandoned completely." He would "prefer a system of patronage and nomination the whole way from entering school to taking an honours degree, to the present deadening and mentally degrading standardized examination system, and this, not withstanding the possibilities of corruption or favouritism" He deplores the fact that the whole trend of education has been to glorify book learning, and to eliminate solitude, silence and contemplation. He would have fewer subjects taught, with "a greatly shortened working day, and time definitely allocated for doing precisely nothing. Secondly, actual lessons in the noble art of contemplation; and thirdly, greater contact with the country."

With regard to agricultural research, Professor Stapledon considers that this should be organized in terms of the basal problems of agriculture itself rather than in terms of subjects like chemistry, economics and so on. "There is no doubt that there is virtue in overlapping: it is bad for a man, and for an institution to feel in sole possession of a problem." He feels the need for "experimental farms, research farms, mad farms. Until we have an agricultural research station as opposed to stations devoted to the sciences, I see little hope of science contributing in full measure to the evolution of the new agriculture. A spirit of adventure and an ability to change with the times is what agricultural education and research must endeavour to transmit to the rising generation of farmers."

Space will not allow of further quotation from this very stimulating book. Criticism is easy, and the author has already been dubbed a visionary. But without vision no progress can be made. The reviewer has the greatest respect and admiration for the philosophical and scientific qualities of the author (who has done so much to compel recognition of agricultural botany as a cultural and useful study), and urges everyone interested in the problems of the country-side to read this book. It is unfortunate, in a way, that it is so full of meat, since on that account the general public may not be attracted to it

D. H. R.

The Sociological Background of Adult Education in Rural Areas. By A. W. Ashby. Life and Leisure Pamphlets, No. 2. Second Edition. 1935. (Published by the British Institute of Adult Education, 39 Bedford Square, London, W.C.1.) Price 6s.

Ever since about the middle of the fourteenth century men and governments have been concerned about what is known as the "rural exodus," or the flow of people from rural into urban occupations. But despite many attempts to stem this flow it has continued almost unabatedly, and even to-day the tendency is as obvious as ever. While much has been said and written about the problem, it has been only within recent years that sociologically minded persons have given it serious and detailed consideration. Professor Ashby has probably given more thought to problems arising out of rural urban migrations than any other authority in this country. He has traced out the decline in the rural population and assigned cogent reasons why the decline has been continuous. The rural population is not composed totally of persons engaged in truly agricultural pursuits, and therefore while there has been a considerable decline in the rural population, the proportion engaged in agricultural occupations has declined at a very much faster rate. The present tendency of industrially and commercially occupied families to reside outside the confines of a town may even lead to an increase in the numbers

residing in rural areas, and yet the agricultural population may and is likely to continue on the downward course which it has so long followed.

The fundamental causes of reduction in the proportion of rural population were, and still are, the improvement in technical processes in agriculture by the expanding use of machine and power production. This process has caused many kinds of workers engaged directly or indirectly in agriculture practically to disappear. These changes in technical and mechanical equipment in agriculture are the fundamental causes of migration. Professor Ashby, however, does not lament the "migration from agriculture" or "the exodus from the land," for he argues that under the prevailing circumstances transfer from agriculture to other occupations was the only method which agriculturalists could use to protect and improve their standards of living, and indeed the transfer has enriched the whole of society.

Nevertheless it is recognized that migration from agriculture and rural districts has left us with many important social problems. It has often been suggested that the skimming off of the best has left us with a physically or mentally impoverished rural population, but Professor Ashby sees no evidence to bear out either of these contentions.

There remain two important questions : What significant differences, if any, can be found in the characteristic mentality of the rural and urban population, and what, if any, are the distinctive features of rural mentality? Influences playing upon the minds of the rural and urban population may differ considerably, yet through the mind of the whole British population there run certain patterns of thought, modes of behaviour, and standards of values which are more or less common in all classes and all environments

It is commonly suggested that the special mental condition of the rural population of this country is that of dullness. But dullness, or what is taken for dullness, may only be slowness. The countryman may be slow in thought and speech, and yet his conclusions may be as logical and sound as those of the more sparkling town dweller.

On the whole, because of residence in small groups and the power of group-approval or disapproval, and because of the lack of opportunity for association between individuals who begin to have radical veins or attitudes, the countryman tends to be socially conservative. "One would like," states Professor Ashby, "to develop such forms of education as would reduce the countryman's social conservatism and raise his industrial and social adaptability. I see very little that need be permanent in the special make-up of the countryman and very little which would warrant special efforts for preservation."

R. H

Farm Buildings. By Edwin Gunn, A R.I.B.A. Edited by H C. Long, B.Sc.(Agric.). Pp. 86 and 38 figures and plates. (Obtainable from H. C. Long, "The Birkins," Orchard Road, Hook, Surbiton.) Price 5s , by post 5s. 4d.

The author has presented the subject in an original and refreshing style. How often the designer of farm buildings is an architect and not an agriculturist, or an agriculturist without architectural knowledge. Many books on the subject deal mainly with the construction of new buildings, but owing to lack of capital and other circumstances the main problem is the adaptation of existing buildings, and this the author has dealt with admirably in his book. The subject-matter is only too brief, but this is compensated for by the precise and accurate manner in which the information is given.

On the other hand, there is a wide circle in which the book would have had increased value, had the references to elementary construction been given in greater detail. For example, at this time when many milk producers

are reconstructing premises, a section, fully illustrated, of the preliminary work, such as levelling, the necessary framework for channels, mangers, etc., and of the actual work of laying and forming the floor channel, concrete mangers, etc., would have been of value to many who do this work by direct labour.

On an important point of detail of cowshed construction, Wiltshire experience indicates that unless there is space for a manure channel of at least 2 feet, with a milking passage of 4 feet 6 inches, it should be dispensed with.

If space had permitted, a summary, rather than a reference to the publications by the Ministry of Agriculture, would have been an advantage. In connection with the construction of the Scandanavian-type house for pigs, the depth of the pen, that is from the trough to the dunging passage, is stated at from 9 to 10 feet. This would appear too wide, and will encourage the pigs to soil the pen, bearing in mind that the capacity of the pen is decided upon by the trough room and not the floor space.

Chapter 8 deals with ventilation in a very full and excellent manner. The subject of ventilation is invariably only lightly touched upon.

It is surprising that the author has not mentioned hollow bricks as suitable for the floor, either in the sleeping pen of the piggery, or the cow-bed in the cow house.

Rather than give a more lengthy review, the recommendation is made for the purchase of this book, which should be of much benefit to architects, landowners, tenant farmers and agriculturists in general.

W. T. P.

Bacteria in relation to the Milk Supply. By C. H. Chalmers, B.Sc., N.D.A. Pp. xi + 192. (Edward Arnold.) Price 6s.

This book deals with the bacteriological control of milk supplies from the point of view of the commercial rather than the medical bacteriologist. It is divided into two parts. Part I deals very fully with the various bacteriological methods used in the examination of milk and water. It also includes chapters on taints and other abnormalities, and the control of dairy plant, together with a very useful chapter on the isolation and identification of organisms commonly occurring in milk. Part II deals with general bacteriological technique, while the appendices contain a list of culture media, bacteriological stains and other reagents, which provide a handy form of reference for a control laboratory. Throughout the book most attention is paid to the practical side of the methods described, to some extent neglecting considerations of their scope and validity.

The book will be of great assistance to the elementary student of dairy bacteriology, as it provides a survey of the bacteriology of milk in a very readable form. The trained worker, entrusted with control work, will find it a useful laboratory manual of the tests commonly applied to milk.

A. L. P.

Insect Pests of Glasshouse Crops. By Herbert W. Miles, M.Sc., Ph.D. and Mary Miles, M.Sc. Edited by H. C. Long, B.Sc. (Agric.). Pp. 174, 86 photographs in 21 plates, 15 text figures. (Obtainable from H. C. Long, "The Birkins," Orchard Road, Hook, Surbiton, Surrey.) Price 8s. 6d. (by post 9s.).

In this book, which has a foreword by Mr. J. C. Fryer, O.B.E., Director of the Plant Pathological Laboratory of the Ministry of Agriculture, the

authors have gathered together a great deal of information about the numerous insect pests which specialize on glasshouse crops. In nine chapters they deal with glasshouse conditions in relation to the occurrence and control of pests, general soil pests, caterpillars and leaf miners, aphides, capsids and leaf hoppers, white fly, mealy bugs and scale insects, thrips and spider mites, eelworm pests, wood lice, earwigs and miscellaneous pests, and methods of pest control in glasshouses. There is also an appendix, giving in alphabetical order a list of the chief glasshouse crops with their associated pests and their characteristic injury. A selected bibliography dealing mainly with recent work is included.

It is impossible to do more than point out the chief features and contents of a book such as this. The subject-matter is simply and practically written, and is not merely a re-hash of previously published work, but includes a great deal of the experience of the authors in dealing with glasshouse pests There can be no doubt that the book will prove very useful for those who have to deal with glasshouse crops, for hitherto there has been no convenient work of reference supplying the essential information that this volume provides.

The book is attractively produced, and the paper is strong and good, the photographs are specially well done. There is a full index.

D. H. R

Colloids in Agriculture. By G. E. Marshall. Pp 184. (Edward Arnold.) Price 5s.

Dr. Marshall has divided this book into three parts. The first deals with the more theoretical and fundamental aspects of colloids in general, the second with the application of these principles to soils, and the third with them in their relation to plant and animal life. The writer has given to agricultural chemists and students a concise account of much of the information which has only been available hitherto in a somewhat diffuse literature, to be found in original papers, textbooks and so on. One of the merits of this book is its simple language and easily readable style, which should commend it to many who have an interest in agriculture outside the narrower limits of the laboratory. The study of this branch of agricultural science has undoubtedly been facilitated by the publication of a book of this nature

T. O W.

Soils. Their Origin, Constitution and Classification. An Introduction to Pedology. By Gilbert Wooding Robinson, M.A (London: Thomas Murby & Co.). Second edition. 1936. Pp. 442 Price 20s.

A fitting tribute to the world-wide reputation of Professor G. W Robinson is the fact that the first edition of his book (published in 1932) has for some time been exhausted. The second edition has just appeared and is produced on lines similar in general to those of the first edition. As the author explains in the preface, many new ideas among pedologists have emerged in the past three years and much literature has been published, making it necessary to modify, recast and considerably enlarge certain sections. Altogether sixty-three extra pages of subject-matter have been added.

What is perhaps most welcome is the addition of more illustrations, from the absence of which it was felt that the first edition suffered. In particular the number of photographs of profiles has been increased, and these definitely assist the description in conveying a clearer idea of the

appearance of typical members of world soil groups. Changes in the text are mainly concerned with additional data in those sections dealing with pedogenic processes, the clay complex, base exchange, soil moisture, soil classification, and the excision of the appendix on soil analysis, which, as the author explains, becomes unnecessary since the publication of C. H. Wright's book.

The author sets out to give his own conception of the various aspects of soil science and, what is more important, the relationships linking them into a coherent story. The book will appeal to many classes of readers, particularly those on the fringe of the subject, who desire to obtain a clearer mental picture of the whole subject. The reviewer strongly recommends the second edition to that wide circle of students who found the first so stimulating, and to those who are about to form contact with the subject for the first time.

The publishers deserve a word of praise for the excellent way in which the book has been produced. W. M. D.

Scientific Horticulture. The Journal of the Horticultural Education Association, Volume IV, 1936. Obtainable from the Editor, South Eastern Agricultural College, Wye, Kent. Price 3s. 6d.

This interesting volume runs to over 200 pages of reading matter, exclusive of the appendices and advertisements, and covers a wide field. Horticultural interests in Scotland receive attention from four contributors, whilst there is the usual run of scientific articles intended for those intimately connected with the horticultural industry Members of the Agricultural Education Association will find much to interest them in the articles on "Methods of Vegetative Propagation," by R. J D Graham; "The Dying of Tips of Potato Sprouts during 'Chitting'," by G. H. Bates and W A. R. Dillon Weston; "Seedling Growth in Partially Sterilised Soil," by W. J. C. Lawrence and J. Newell; "Showing Educational Films in Daylight," by N. B. Bagenal. The Papers on "The Effect of Length of Day on the Flowering of Plants," by F. G. Gregory, and "Vernalization," by O. N. Purvis are of particular interest in view of the article on the same subject in this volume of AGRICULTURAL PROGRESS. D. H. R.

BULLETINS AND REPRINTS

VOLUME IX—XII.

Agricultural Education authorities are invited to send copies of their publications to the Editor for inclusion in this section. To ensure publication they should be sent not later than the middle of January in each year.

UNIVERSITY OF ABERDEEN.

The North of Scotland College of Agriculture.

"Sheep-Sick Pastures," by D Robertson.
"The Large Roundworm of Pigs," by D. Robertson
"Farmers and the Warble Fly Problem," by D. Robertson.
"Worm Infestation of Lambs" (Bull. No. 39), by D. Robertson.

UNIVERSITY OF CAMBRIDGE.

School of Agriculture.

Memoir No. 7. This Memoir, which is published under the general editorship of the librarian of the School, represents an attempt to present as succinctly as possible the contributions made by members of the Staffs of the School of Agriculture and its Associated Institutes to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented, and to act as a complete record of papers published. Each summary is compiled by the author of the paper and is presented, so far as the subject-matter will allow, in a non-technical form in order to be of value to the general body of farmers interested in the more recent developments of agricultural scientific research in general, and of the activities of this Department in particular.

Requests for further information or criticism arising out of the summaries should be referred to the individual author concerned, criticisms and suggestions for the improvement of the Memoir itself should be addressed to the librarian of the School.

UNIVERSITY OF DURHAM

Armstrong College, Newcastle-on-Tyne, 2.

Exhibit of the Dept. of Agriculture and the County Councils of Cumberland, Durham, Northumberland and Westmorland at the Royal Show, Newcastle-on-Tyne, 1935.

UNIVERSITY OF EDINBURGH.

Edinburgh and East of Scotland College of Agriculture,
13, George Square, Edinburgh.

Report on the Work of the College, Year ending 30th September, 1935.
Guide to Boghall Experimental Farm, 1935
"Plant Pathology": Notes from the Botany Dept., by J. A. Macdonald.
"Miscellaneous Notes from the Dept. of Botany," by Wyllie Fenton.

HANNAH DAIRY RESEARCH INSTITUTE, KIRKHILL, AYR.

Sixth Annual Report for the Year ending 31st March, 1935.
"An Enquiry into the Design, Operation and Efficiency of Pasteurizing Plants," by A. W. Scott and Norman C. Wright.

HARPER ADAMS AGRICULTURAL COLLEGE, NEWPORT, SHROPSHIRE.

College Prospectus, 1935.

Farm Guide, Season 1935.

Report of the Advisory Departments. A Review of Advisory Work in the West Midland Province, 1934–35.

"Milk as Food for Livestock," by C. Crowther.

The Work of the Harper Adams Pig Feeding Experimental Station, Autumn, 1933—Spring, 1935, by C. Crowther and T. S. Wright.

The Visit of the International Society of Soil Science, 1935.

Utility Poultry Journal, Vol. 20.

SEALE-HAYNE AGRICULTURAL COLLEGE, NEWTON ABBOT, DEVON.

Department of Plant Pathology. Pamphlet No. 44. Eleventh Annual Report, 1934.

Farmers' Report, No. 11.

SOUTH-EASTERN AGRICULTURAL COLLEGE, WYE, KENT

Report of the Department of Economics. Pamphlet No. XXII. "Financial Problems in Poultry Keeping," by James Wyllie.

The Journal, No. 36, July, 1935. The contents include:—"The Microscopic Examination of Cattle Foods—Some Oil-containing Seeds," by S. T. Parkinson; "Soil Consolidation in a 'Seeds' Ley," by R. M. Harrison, "The Vegetative Propagation of Pyrethrum," by A. B. Cormack; "A Local Grass (*Koeleria cristata, Pers.*)," by F. R. Russell; "'Cats-Tails' A New Variety of Hop," by Prof. E. S. Salmon; "The Downy Mildew of the Hop in 1934," by Prof. E. S. Salmon and W. M. Ware; "The Control of Apple Scab: Allington Pippin and Newton Wonder, 1934," by W. Goodwin, N. H. Pizer, E. S. Salmon and W. M. Ware; "Investigations on Machinery used in Spraying. Part 2, Nozzles," by Cornelius Davies and G. B. R. Smyth-Homewood; "Studies on the Ovicidal Action of Winter Washes—1934 Trials," by M. D. Austin, S G. Jary and H. Martin; "'Potato Sickness' on Allotments of New Romney," by S. G. Jary and S. J. Travers; "Bordeaux Mixture—Nicotine Combinations against Aphis and Apple Scab," by M. D Austin, S. G. Jary and H. Martin; "Investigation on the Insect and Allied Pests of Cultivated Mushrooms—IV–V," by M. D. Martin and S. G Jary; "Pears—Their Pollination; The Relative Order of Varieties; Their Cross Fertilization and the Insect Visitors to the Blossoms," by Cecil H. Hooper, "Grass Drying in Hop Oasts, 1933–34," by A. H. Burgess and N. L. Tinley; "The Field Work of Agricultural Crop Trials," by N. L. Tinley; "Effect of Different Methods of Mixing Milk," by H. Barkworth; "Insulated Containers for Milk Samples sent by Post," by H. Barkworth; "Relationships of Roots, Soil Profile and Irrigation in the Sudan," by F. E. Kenchington; "A Soil Survey in the Valley of the Great Stour, Kent," by W. O. Sharp; "Soils and their Utilization," by W. O. Sharp.

The Journal, No. 37, January, 1936. Research and Advisory Departmental Reports.

DAUNTSEY'S SCHOOL, WEST LAVINGTON, WILTS.

Rural Studies and Practical Work (including Report on Experiments, 1934–35).

ESSEX COUNTY COUNCIL.

East Anglian Institute of Agriculture, Chelmsford.

Annual Report, 1934–35.

Calendar, 1935–36.

Register of Egg Records, County Egg Laying Trials, 1933–34, 1934–35.

Report of the Fifteenth County Clean Milk Competition, 1934.
Report of the Sixteenth County Clean Milk Competition, 1935.
Bulletin No. 3. "The Zone of Soil to be Fertilized for Sugar Beet," by F. Knowles and J. E. Watkin
A Fruit Store for the Small Commercial Grower.

ISLE OF MAN.
Board of Agriculture, Knockaloe, Peel.

The Manx Journal of Agriculture, Vol. II, No. 2, July, 1935. Vol. III, No. 1, January, 1936.
Report of the Board of Agriculture, Year ended 31st March, 1935.

NORTHUMBERLAND COUNTY COUNCIL.
Agricultural Education Committee, 8, Westmorland Road, Newcastle-on-Tyne.

Bulletin No. 48. "Guide to Cockle Park Agricultural Station, 1935," by J. A. Hanley.
"The Meadow Hay Crop," Report on Trials in Northumberland, by H. C. Pawson and A. R. Wannop
Transactions of the Discussion Societies, Vol. V, 1934–35.

SHROPSHIRE COUNTY COUNCIL.
Agricultural Education Office, College Hill, Shrewsbury.

Shropshire Agricultural News, Vol. II, Nos 1, 2, 3, 4.

WORCESTERSHIRE COUNTY COUNCIL
Department of Agricultural Education, County Buildings, Worcester.

Agricultural Quarterly Chronicle, Vol. III, Nos 2, 3, 4.

REPRINTS.

CORNER, H. H.: "Agricultural Experiments in Berwickshire, Roxburghshire and Selkirkshire, 1934 Report," *The Southern Reporter*, Selkirk

CORNER, H. H.: "Grass Silage," *The Border Mail and Gazette*, 29th June, 1935.

FENTON, E. WYLLIE: "The Transition from Woodland and Moorland Grassland in the Spey Valley and elsewhere," *J Ecol*, Vol. XXIII, No. 1, February, 1935.

FENTON, E. WYLLIE: "The Need for a Permanent Organization for Undertaking Periodic Botanical Surveys of Great Britain," *The Scottish Forestry Journal*, Vol. XLIX, Part 2, October, 1935.

GIBSON, T.: "An Investigation of the *Bacillus Pasteuri* Group."
(1) Description of Strains Isolated from Soils and Manures
(2) Special Physiology of the Organisms. *Journal of Bacteriology*, Vol. XXVIII, No. 5, September, 1934.
(3) Systematic Relationships of the Group. *Idem.*, Vol. XXIX, No. 5, May, 1935.

GIBSON, T.: "The Urea-decomposing Microflora of Soils."
(1) Description and Classification of the Organisms.
(2) The Numbers and Types of the Organisms as shown by Different Methods.

HEDDLE, R. G., and WALKER, L. M.: "Management of Hill Pastures—Mechanical Treatment of Rough Hill Pasture," *S.J.A.*, Vol. XVIII, No. 2, April, 1935.

LESLIE, J. C.: "A County Scheme of Agricultural Education," *Agric. Progress*, Vol. XII, 1935.

LESLIE, J. C., and EWING, D. J.: "The Agriculture of Essex," *Agric. Progress*, Vol XII, 1935.

MUSKETT, A. E., CAIRNS, H., and CARRUTHERS, E. N.: "Further Contributions to the Fungus flora of Ulster," *Proc. Roy. Irish Acad.*, Vol. XLII, Sec. B, No. 4, September, 1934.

ROBERTSON, D.: "The Stem Eelworm Disease of Oats," *S J.A.*, Vol. XVIII, No. 1, January, 1935.

ROBERTSON, D., and FRAZER, ALLEN H. H.: "On the Incidence of Stomach Worms in Lambs in the North of Scotland, and their control by Progressive Sectional Grazing," *J. of Helminthology*, Vol. XI, No. 4, October, 1933, pp. 187–194.

WALKER, L. M.: "Mechanical Treatment of Rough Hill Pasture," *S.J.A.*, Vol. XVIII, No. 2, April, 1935.

WALKER, L. M.: "The Combine Harvester-Thresher in East Lothian," *S.J.A.*, Vol. XVIII, No. 3, July, 1935.

WALKER, L. M.: "The 'Gyrotiller' in Scotland," *Idem.*, Vol. XVIII, No. 1, January, 1935.

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"... Pater ipse colendi
Haud facilem esse viam voluit ..."—VIRGIL

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AGRICULTURAL PROGRESS VOL. XIV (PART I)

CONTENTS

IN THE BEGINNING: A Series of Articles dealing with the Development of Agricultural Educational and Research Institutions.

1. ROTHAMSTED EXPERIMENTAL STATION

BY SIR E. JOHN RUSSELL, D.Sc., F.R.S., *Director*

The Rothamsted experiments were initiated in 1843 by John Bennet Lawes, an English country squire, who lived in the beautiful old manor-house of Rothamsted—one of the stately homes of England. The times were bad for farmers, and as Lawes depended on farming, his purpose was to get more out of the land. At that time the yield of wheat on the estate, and probably in England as a whole, was about 20 bushels per acre, but in some seasons it fell much lower.

Lawes had a taste for making agricultural experiments, and great luck in that his experiments nearly always succeeded. He knew a little chemistry and something about the composition of farmyard manure, then the regular manure on all farms and still one of the best. He had found by experiment that one of its constituents, nitrogen, could advantageously be given to crops in the form of sulphate of ammonia, a by-product in the manufacture of coal-gas. He further experimented with bones, which had worked marvels on some of the English pastures, but had failed at Rothamsted: he found that if they were treated with sulphuric acid they became effective, being converted into the substance then called superphosphate of lime. At that time bones were dear but rock phosphate, which had only just been discovered, was cheap, and Lawes found that on treatment with sulphuric acid it yielded the same superphosphate of lime as did the more expensive bones. He patented the process, set up a factory near London, and made artificial manures for the first time in history. For many years the whole superphosphate industry was in his hands and he amassed a considerable fortune. Lawes continued the field experiments on his farm, and in 1843 brought to Rothamsted a young chemist, Joseph Henry Gilbert.

Lawes and Gilbert were strikingly different. Lawes was a man of great vision, who could lay down the general lines and work out the bold outlines of a scheme, but he had little capacity for detail. His notebooks are mainly blank spaces, where he

meant to enter observations, but did not. Nevertheless, as you read through the notes, in spite of their brevity you can see exactly what he was trying to do, and although the observations are short, you can tell from them pretty well how the investigation was going. Though the record lacks the precision that gives high scientific value, it indicates clearly the solution of a practical problem.

Gilbert was entirely different in character. He lacked the imagination and the power of laying down bold outlines, but he had a wonderful aptitude for detail. His notebooks are a mass of figures so crowded that you cannot tell what the investigation is about or what he was striving to accomplish. The figures, however, were accurate, the observations carefully made and carefully recorded. He had no faith in short cuts, and to the end of his days would never touch logarithms: all calculations were done by long multiplication and division.

The combination of Lawes and Gilbert was almost ideal for scientific purposes. They worked together for 60 years, the longest scientific partnership in history; Lawes's ideas, with Gilbert's painstaking skilful work and close attention to every detail, ensured that the greatest accuracy possible at the time was attained in all the experiments. This fine combination of two distinct qualities gave the Rothamsted experiments the character they have always possessed. For the first 12 years Lawes and Gilbert worked in a barn fitted up as a laboratory; here the first superphosphate was made from imported mineral phosphate and sulphuric acid; it was tested on the field, now well known as Barnfield, which lay just outside.

One great problem which Lawes and Gilbert set out to solve was to account for the fertilizing value of farmyard manure. The fact was well known, but there was no satisfactory explanation. Lawes and Gilbert proceeded by a method that still, after 80 years, remains our best: they analysed the farmyard manure and made vegetation tests with its various components, organic matter, nitrogen compounds, and ash constituents, potassium, calcium and magnesium salts, phosphates and silicates, etc. The old idea had been that the fertilizing value lay in the organic matter or "humus," but Liebig, in 1840, had argued brilliantly against this view, and suggested instead that the ash constituents, especially the potassium, calcium and magnesium salts, were the effective agents. Lawes and Gilbert were prepared to recognize the necessity for these mineral salts, but insisted that the nitrogen compounds were equally required. To put the matter to a test they laid out four plots of ground, receiving respectively no manure, farmyard manure, ashes

of an equal amount of farmyard manure, and these ashes plus a nitrogen compound (ammonium sulphate). The results were as follows:—

PRODUCT OF WHEAT PER ACRE. BROADBALK FIELD. ROTHAMSTED, 1844.

	Grain. Bushels.	Straw. Cwts.
No manure	16	1,120
Farmyard manure (14 tons per acre) ..	22	1,476
Ashes of 14 tons of farmyard manure ..	16	1,104
Ash constituents plus a nitrogen compound (ammonium sulphate) up to	26¼	1,172

The experiment showed that farmyard manure owes its value, not to the organic matter, as was for long supposed, nor to the ash constituents, as Liebig had suggested, but to the ash constituents plus nitrogen compounds.

This discovery was of the greatest importance to plant physiology, but Lawes and Gilbert did not follow it up in that direction. Instead they applied it at once to an important agricultural problem then ripe for solution. There was then (as nearly always now) a shortage of farmyard manure on farms, and agriculturists had for generations sought for substitutes, but with little success. Lawes and Gilbert saw that the mixture of ash constituents and nitrogen compounds would form an effective and more concentrated substitute, and, further, it could be obtained in very large quantities, and of course independently of farmyard manure. Geologists had discovered vast deposits of calcium phosphate, which chemists had shown how to render soluble. Engineers were developing the manufacture of coal-gas and producing large quantities of ammonium sulphate, while potassium compounds could be obtained without difficulty from wood ashes. Lawes and Gilbert therefore proceeded to experiment largely with these substances, while Lawes set up the first factory for producing superphosphate.

At first farmers looked with some misgiving upon this new kind of manure (which was called "artificial manure" to distinguish it from farmyard, or "natural" manure); it seemed incredible that a small amount of powder without smell or taste could act as potently as a large quantity of the old-time, richly odorous, farmyard manure. But they soon came to recognize its value, and before long they were using many thousands of tons a year. It is safe to say that the remarkable development of British agriculture which took place between 1843, when Rothamsted began, and 1870 would have been impossible without artificial fertilizers. During that period the British farmers not only kept pace with the

growing needs of the population, but they helped to change the "hungry forties" into the more plentiful seventies. The use of artificial fertilizers is now developed throughout the civilized world, and the industry has attained enormous dimensions.

Lawes and Gilbert went on for 20 years before they published much, and then they wrote up a full account of the experiments. Now-a-days it would be impossible for any experimenter to continue so long without publication, but Lawes and Gilbert were quite independent of any Government or other organization, everything being done at Lawes's expense: hence they were able to please themselves. They then continued the experiments for another 20 years, and at the end of 50 years they wrote an elaborate account of their results. Having done the field-work for 50 years, they continued it to the end of their lives. In 1902 Sir Daniel Hall was appointed Director, and he continued the experiments till he left. I followed him in 1912 and have continued them ever since, and as a result we are now growing the 93rd crop of wheat, the 84th crop of barley, the 80th crop of hay and the 58th crop of mangolds, the treatment of each plot being the same year after year. It is this long continuance of the experiments on the same ground that gives the Rothamsted field plots their distinctive character. Nowhere else in the world is there a set anything like as extensive or as old, the nearest being American experiments commenced many years later at Wooster, Ohio; at State College, Pennsylvania; at Champaign, Illinois; also a second set begun by A. Voelcker with Lawes' and Gilbert's co-operation at Woburn in England, and now brought back under Rothamsted management.

As the use of artificial fertilizers spread there arose, as one might expect, many problems of great scientific interest or technical importance. Thus it soon appeared that weather conditions profoundly affect the response of crops to artificial fertilizers. One and the same fertilizer mixture which in one season gave results fully equal to, or even surpassing, those of farmyard manure, would on the same farm, and even in the same field, prove a failure in another season.

In agricultural field work the factors do not vary one at a time, or even two or three at a time; there may be half a dozen variables.

Statisticians have during recent years been evolving methods for dealing with cases where several factors vary simultaneously. These methods have been applied by R. A. Fisher to the Rothamsted field data, and he has been able to trace certain statistical regularities which foreshadow the possibility of important developments.

Thus, the yields on the Broadbalk Wheat Field vary every year, apparently in a most erratic manner. But analysis of the figures showed that the factors causing variation could be disentangled and expressed quantitatively; there were slow changes in the field, such as variations in the amount of weeds, etc.; deterioration of soil; and annual factors such as rainfall, etc.

Having disentangled the factors, Fisher proceeded to analyse the effect of rainfall; other factors have since been studied. The method provides fundamental data for a science of agricultural meteorology whenever it is found practicable to develop this. The present difficulty is, however, that the existing measurements do not adequately describe the growing characteristics of a season.

The introduction of statistical methods for studying the field data constitutes one of the new developments at Rothamsted which we believe will have far-reaching consequences. For statistical methods not only ensure that the field data shall be thoroughly explored to extract as much information as they will yield, but also enable the experimenter to improve his experiments and make his results more trustworthy; they enable him to calculate the probable value of his data. The old field plots which gave the first information about artificial fertilizers are not very accurate; they cannot measure differences of less than 10 or 15 per cent., nor can their trustworthiness be readily calculated. In the first development of a subject when nothing is known, rough methods are often very useful. But as knowledge grows these methods become unsuitable, the scientific workers and the farmer both need greater accuracy than 10 or 15 per cent., the farmer because his margins of profit are cut very finely. The modern methods of field experiment worked out at Rothamsted are capable of revealing differences of the order of 2 per cent.

Microbiological investigations were begun by Warington at Rothamsted about 1879, as the result of analyses of the drainage water from some of the plots. When Lawes and Gilbert began their experiments they used sulphate of ammonia as their nitrogenous fertilizer, but the compound that appeared in the drainage water was always a nitrate. This had already been demonstrated by the French chemists about 1860, and the question arose: how was the nitrate formed? After many years of discussion the answer came, again from France, that it was formed by micro-organisms which oxidized the ammonia. Warington spent 10 years in trying to isolate the organisms, but without success: the problem was solved by a young Russian bacteriologist, Winogradsky. Warington had, however, shown that the process occurs in two stages: first the

formation of a nitrite and then its oxidation to a nitrate; he also obtained much valuable information about the properties of the organisms concerned and he isolated numbers of other organisms from the soil.

Lawes died in 1900 and Gilbert in 1901. In 1902, A. D. Hall was persuaded to leave Wye and take up the Directorship. He has left on record his own impressions and I cannot do better than quote them:—

> "My knowledge of Rothamsted before my appointment as Director in 1902 was limited to a few occasions when I had gone to see the plots or to get samples of soil for some work on comparative solvent powers of various weak acids as measures of 'available' phosphoric acid and potash. Sir Henry Gilbert allowed me to operate with an auger on the classic plots, though he did not conceal his contempt of it as a sampling tool, just as he politely ignored my results when later I tried to discuss them with him.
>
> "I was thus not unaware of the rigidity of the outlook which had been maintained for many years at Rothamsted, but I will confess that my heart sank when I did come to take possession of the laboratory. A good idea of it may be found from the photograph in Edwin Grey's book which shows how much more like a museum than a laboratory it was, but that picture hardly suggests the mellow dustiness that radiated from the vast stove occupying the centre of the room. At one end, Dr. Miller had a little room that would be recognized as a laboratory; at the other end Grey had his nitrogen room, in which not too long before the Kjeldahl process had replaced the old combustion method. But the main room was chiefly given over to grass sorting and had no benches with gas and water laid on. Indeed, after Warington had left the laboratory in 1890, no general chemical work had been going on: Gilbert was entirely preoccupied with the nitrogen question and wanted no more than certain routine determinations.
>
> "For years Gilbert had not worked in the laboratory; he came across from time to time when certain things were prepared for his consideration. Otherwise he digested the results in his own house in the morning, rested in the afternoon, and began work again after an early dinner, when he would dictate to Dunkley to any hour of the night. It was a soul-destroying routine saved by the exceptional human quality of the men engaged in it.
>
> "We were short-handed and desperately poor. The united wisdom of the Trustees, some of the most eminent bankers in the country, had invested the Trust capital in super-safe securities which yielded a bare 3 per cent. and had depreciated something like 30 per cent. as a consequence of the South African War. The Government was appealed to, and an interview was procured with Mr. Hanbury, then President of the Board of Agriculture. He told us severely that it was to Rothamsted the Board looked for scientific information for the needs of the industry, and that it was our duty to collect any money we required. Afterwards Sir Thomas Elliot, then Secretary to the Board, in one of the very few occasions in the course of a long acquaintance in which I knew him to take off his rôle of official reticence, confided to me that agriculture in England was dead and the Board's business was to bury it decently."

But Hall was convinced that agricultural research could no longer be done single-handed. The problems were too complex for one man to tackle alone. He began the process of expansion which ended in his giving up scientific for administrative work.

He goes on:—

> "Mr. Lloyd George, then Chancellor of the Exchequer, came to see our work; it helped to kindle his passion for construction work for agriculture and soon after he launched the Development Commission. It brought an unheard-of expansion to Rothamsted as to the whole course of agricultural research in England. For a time I tried to be a Commissioner and Director, but I soon found that a man cannot busy himself with committees, enquiries, and schemes, and at the same time, think. Research demands that you must brood over it. So I had to choose and it seemed desirable that I should go and help to parcel out the straw from which others could make bricks. But to Rothamsted I owe the best ten years of my life."

Sir Daniel Hall left in 1912 and I was appointed Director. I had been working for some time on the partial sterilization of soil and had made many experiments showing the increased productiveness that resulted. Quite unexpectedly the possibility of important practical qualifications opened out. A well-known tomato and cucumber grower in the Lea Valley wrote telling me about the sick soils that were then causing much trouble in that important glass-house region and raised the question whether partial sterilization would be a cure. That was the beginning of a long friendship which ended only with his death and which introduced me to a keen, vigorous group of growers whose problems still provide good material for us. Some of his sick soil was brought along and treated; it was then planted with tomatoes, and he was invited to come and see the results. They were so satisfactory that demonstrations were arranged in the Lea Valley and periodically visited; they were successful, but they had raised numerous other problems calling urgently for investigation. Almost immediately after my appointment some of the growers asked me to arrange for the work to be done. I soon saw that it could not be run from Rothamsted; the only hope of success was to start a local experiment station. I felt equally certain, however, that if the station were started it must be as closely associated with Rothamsted as possible, but it was more difficult to decide whether it should be a sub-station of Rothamsted or an independent organization of which we should nominate an important proportion of the Committee. Either course committed us to the idea of expansion and the decision was needed at once. The legal adviser was for avoiding all expansion: "Sit tight, keep within your four walls, and no one is likely to dislodge you," was the substance of his advice.

While I was debating what course to recommend to the Trust Committee, the matter solved itself quite unexpectedly. The old laboratory began to tumble down. Great cracks appeared in the walls, a subsidence began and one of the doors refused to open;

the architects examined the structure and told us that if the tie rods were loosened, the whole building would probably collapse. I felt it a sacrilege to touch the place, yet there was no option; it would have cost very much to restore and would never have made a modern laboratory. Rebuilding was unavoidable. Professor Armstong suggested, and the Committee agreed, that it was most opportune to erect good modern laboratories on an adequate scale. It was high time, for the old place was appalling. Often I had gone home at night with a sick headache through working in the stuffy, unventilated, badly heated chamber that was my room, and I wanted to ensure that nothing of the kind should happen again. So we made plans as good as we could. Moreover, we meant to have a library, for Rothamsted then possessed only a few books. Dr. Miller was a born bibliophile with an amazing knowledge of agricultural literature, which it seemed a waste of good material not to use. No funds were available.

Miller had a brain-wave and pointed out that 1915 was the centenary of the birth of Gilbert, and 1916 that of Lawes; why not make a centenary effort? The cost of the new building was to be £12,000 (building was then only about half its present price) and the Development Commission would give us one-half if we could raise the other. The Committee approved and we started raising the money; it was a new game to me, but the laboratories were begun and the die was cast definitely for expansion.

The library started in earnest when one morning Miller arrived in great excitement with a catalogue he had just received. Messrs. Quaritch had purchased the late Sir Walter Gilbey's agricultural library: a gorgeous collection of old books. We did not stop to read the catalogue, but went straight up to town, and secured almost all the books, far out-spending the intended allocations of several years. I rather caught fright and left two very desirable books, one a choice fifteenth-century MS., of Crescentius's "Agriculture" for which £250 was asked, the other a perfect copy of Fitzherbert's "Husbandry," 1432, offered at £35. Being still new I did not know how to cope with such a situation. Two days later I had collected £35, and went back for the Fitzherbert, but it had gone, a purchaser having come a few hours after our departure; he refused to sell it to us. Fourteen year afterwards the same copy was again on the market, this time at Liverpool, and the price was £120; but it is now safe in our library. The Crescentius I never saw again, nor could Quaritch help us; but the life of Rothamsted is long and we may yet possess it.

Then came the war; Martin and Daish, who held Territorial

commissions, went off at once. Lewin and Keen quickly secured commissions; then Eames went, and gradually all the fit men followed. Martin never returned, and Lewin came back only twice on short leave. As time went on the munitions and the food problems became more and more serious, and there was more and more need of scientific help. I became a Technical Adviser to the Food Production Department, and Scientific Adviser to the Ministry of Munitions, and to various of the Government Departments that sprang up, and much experimental work had to be done at Rothamsted, besides the carrying on of the permanent field experiments which we had no intention of discontinuing.

Women took the place of men. Mrs. Eames ran the farm and had the distinction of making the only profit ever obtained before or since, and Ruth Gimingham became Secretary, managing most economically and keeping all accounts with the strictest accuracy; Mary Glynne, Violet Jackson, Helen Adam, Lettice Crump, and, of course, Miss Brenchley, worked like trojans in the laboratories, while Miss Johnson become Private Secretary. It was a most strenuous time. Rymer-Roberts, Crowther, and Tattersfield came later.

The war gave the opportunity of showing what science could do in agriculture and after it was over there came the chance of greater usefulness for Rothamsted which involved further expansion. The laboratories started in 1914 for soil and plant nutrition were finally completed in 1919, and opened by Sir Arthur Griffith Boscawen, and a further block of laboratories was put up for Plant Pathology and opened in 1925 by Lord Bledisloe.

The Woburn Fruit Farm was taken over and maintained so long as Mr. Pickering lived, in order to allow him to complete the experiments which he had carried out for some 20 years on the growing of fruit trees. With his death the farm was given up. Shortly after, however, we took over the Royal Agricultural Society's Experimental Farm of 120 acres with its laboratory and pot culture station, also at Woburn. This we continue to hold, Dr. Mann being in charge.

The expansion was accompanied by surprisingly little trouble or friction: the new-comers speedily assimilated the old spirit and tradition, with little of what is euphemistically called "growing pains." The broad principle underlying the expansion is that the proposed work must be related to our existing work and that it must be worth doing for its own sake. But a further rule has been rigidly kept. The station must not grow too large. Its size must be such that every member of the staff can know every other member; that all can meet daily at tea for conversation and discussion, and the

Director need never have to make the mistake of asking A to do something that B could do better. In particular, no commercial exploitation is undertaken; this is always done far better by business organizations than by research institutes. A policy of splitting off sections of the work has always been adopted as soon as this seemed practicable.

The first colony to be set up was the Lea Valley Experiment Station to deal with glass-house problems, which has been developed so successfully by Dr. Bewley, who left us to take charge. Then came the setting up of Adco to exploit the discovery by Hutchinson and Richards of a method of making artificial farmyard manure; this henceforward occupied Richards's time. Then Thornton's lucerne inoculation was handed over to Allen and Hanbury for exploitation; that also has been successfully done. Imms's work on biological control of certain pests in New Zealand was passed on to Farnham Royal. The method has proved entirely satisfactory and it will be used further. No director of a research station should be afflicted with megalomania.

In the last few years there has, however, been an important widening of the scope of the Rothamsted work. As the fundamental investigations developed they were found to have useful applications elsewhere also; there came repeated invitations from the United States to go over there and lecture on the Rothamsted experiments. The Rockefeller Foundation increased our accommodation for post-graduate workers by giving us a large range of glass-houses. Requests came from the Sudan, Palestine, Australia, New Zealand, South Africa and India for personal visits and discussions with experts on the spot. Investigations of Empire problems were made at the request of those most concerned, the additional appliances and staff being provided by the Empire Cotton Growing Corporation, the Empire Marketing Board, and others; certain manurial problems, insect problems, virus diseases, and a bacterial disease of cotton have been studied in detail. More important still, when the Imperial Agricultural Research Conference was called in October, 1927, one of its recommendations was the establishment of an Imperial Soil Bureau at Rothamsted to supply information on problems connected with soils and fertilizers to all agricultural departments and research workers in the Empire. The Bureau is now in full operation with Mr. G. V. Jacks as deputy-director. This serves as a valuable link with other soil workers and has greatly strengthened the resources of Rothamsted.

Finally, a few words must be said about the recent purchase of the Rothamsted estate. It is not generally known that the land on

which the Rothamsted laboratory stood and the fields belonged to the Lawes family and not to the Rothamsted Committee. They were leaseholders only. With the growth of Harpenden the Rothamsted land began to have prospective building value, and as our leases came to an end we should almost certainly have difficulty in renewal. In any case the station was becoming too important to allow of any risks, and of course we knew that once the land got into the hands of "estate developers" our doom would be sealed; no considerations of any sort would be allowed to stand in the way of their profits. We had often at Rothamsted discussed the situation and I hoped to be able to clear it up in my time. The opportunity came.

One morning at the beginning of May, 1931, my telephone bell rang, and the office girl announced that the Public Trustee wished to speak to me. I knew that he managed the Lawes-Wittewronge Estate, to which all our land belonged except part of the Director's garden and the few frontages that I had from time to to time bought, and, as we had recently had negotiations about a footpath and a fence, I thought we were to discuss some further detail. But it was Sir Oswald Simpkin himself speaking, so I guessed it must be something bigger.

Our conversation lasted less than the statutory three minutes, but it was important enough. "We are proposing to sell the estate," he said. "Would you like to buy your part?" There was, of course, only one answer, "Certainly; how much do you want for it?" "For the fields you occupy about £10,000, but we should require you to buy the house as well; this would cost about £12,000, a total of £22,000 altogether." But I remembered that our holdings lay in four separate blocks and we should have a very unworkable estate unless we acquired the intervening land, so as to be able to put a ring fence around ourselves; further, the house would be a very white elephant unless we could also secure the park-land in front of it and Knott Wood at the side and the back. I put this to the Public Trustee, and we agreed to meet and discuss the proposal more fully. But we should be prepared to purchase if we could agree about the price. So I put down the telephone and went back to my work.

A few days later Sir Oswald, Sir Charles Howell Thomas (Secretary of the Ministry of Agriculture) and myself lunched at the Union Club in Carlton House Terrace and got down to details.

It is unnecessary to recount the steps; the negotiations with the owners and the Ministry. Sir Edwin Savill acted for us and before long we had mapped out the area we wanted, 527 acres in all, and had agreed on a price, £30,000; there would, however, be additional

items which would bring it up to about £35,000. In ordinary circumstances half of this would have come from the Government, but the crisis was still on and all capital grants were banned; we therefore had to raise the whole of the money ourselves. It was a peculiarly difficult time because everybody's assets had been "frozen" by the crisis and some of our advisers thought the task would be impossible. However in 1934 we decided to try.

The Press helped us most generously. In dealing with them, I fear I made several bad blunders through my ignorance of Press etiquette, but in extenuation I pleaded that I had spent far more of my life on the field and on the farm than in Fleet Street, and as a countryman all was forgiven me.

We had some anxious days, as time was limited and money came only slowly. Then Sir Bernard Greenwell set the ball moving with £1,000 and this at once gave more publicity to our appeal. Happily for us, Mr. Robert McDougall had just disposed of his well-known milling business and was proposing to use most of the proceeds for public purposes. He saw our appeal and the editor's commendation in the *Manchester Guardian*, and having occasion to be in London, called on Sir Thomas Middleton at the Development Commission to ask about Rothamsted; he had with him a few pages from the Commission Report describing our work, but he wanted to know more. Sir Thomas was able to satisfy him, and he then announced his intention of giving £15,000, on certain conditions with which fortunately we were able to comply. He not only did this, but he also informed our good friend Sir Halley Stewart of his intention, and as Sir Halley was in any case interested, his Trust added £5,000 on the same condition.

It is impossible to over-estimate the value of the co-operation which the Press so generously gave. As fast as we could send out "copy" it was taken up; in those hectic days Rothamsted was "news." A paragraph on the progress of the appeal, a list of the last few donations, a plan for ensuring success; all were accepted. A hundred letters a day or even more, all separately typed and signed, would often be sent out. Some of the big banks put up copies of the appeal in all their country branches; collections were taken from farmers on market days; rural school-teachers spread the news in the villages and organized help. Some of the donations sent in were accompanied by most charming letters. There was 1s. 9d. collected in a country school from children who knew about our work, partly through our broadcasting, but mainly through what their teacher had told them. A New Zealand farmer on a flying visit to England heard about the trouble and sent along £1; he was

nearly spent up, or would have sent more. Many working farmers sent in 10s., £1 or £2; all classes of people helped.

In the end the whole amount needed, not simply £30,000, but the £35,000, was collected several days before the appointed time, and on the 18th May, 1934, the purchase was duly completed. The total cost of the appeal had been only £40.

This generous response of the agricultural public will always remain in our memories at Rothamsted as a noble recognition of the work that has been done, and a great incentive to further efforts to deal with the tasks that lie before us.

LAND RECLAMATION IN SCOTLAND*

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In countries, such as Britain, with an old civilization, the best land has already been reclaimed, but there are still great areas of waste and semi-waste land capable of better utilization.

In Scotland in the seventeenth century most of the cultivated land of to-day did not exist; there was merely a patchwork of cultivation, great stretches of moorland, and miserable grazing land. Most of the country was bare, for many of the forests had been destroyed by fire and warfare, and the ground had deteriorated into swampy wastes. The cultivated areas were farmed in a wretched way. The land nearest the cultivators' houses, the "infield," was kept constantly under crop and received all the farmyard manure. Oats and bere were the principal crops and the yields of grain, as a rule, were very poor—perhaps four seeds for every one sown. The greater part of the farm, often four-fifths of it, consisted of "outfield" which never received manure except from the folding of sheep or cattle. Part of the "outfield" was cropped and grain was grown on it for four or more years in succession; it was then allowed to rest for a spell of seven or eight years. The crops on the "outfield" were naturally even more meagre than on the "infield," the yield of grain being sometimes as low as two seeds for one sown, and the crop was often fed unthreshed to the animals.

Another feature of the agriculture of that time was the "run-rig" system. There were rigs or ridges of land with the soil heaped high in the centre and hollows or ditches between them. The rigs were usually held alternately by different tenants and one man might have several rigs scattered over the holding. Much of the land was entirely unenclosed, drainage was bad, implements were extremely primitive and housing conditions miserable. The land was full of weeds and cultivation was done by means of a cumbersome wooden plough drawn by a team of oxen, but in many places the foot plough or breast plough was used. The harrows were made of wood and sometimes were drawn by men or women; reaping was done by the sickle and threshing by the flail.

* From a paper read at the July meeting, Glasgow, 1936.

The Revolution in Agriculture.

This primitive form of agriculture was general in Scotland at the beginning of the eighteenth century and persisted in many places until the nineteenth century. The total area under cultivation was small and much of what was under cultivation was little better than waste land. Then came the agricultural revolution, which led to the reclamation of great areas and changed the face of the country. Various factors contributed to this change, but the principal were greater markets, good prices, increased transport facilities, new crops and better methods of cultivation. The industrial developments in Scotland led to an increase in the population of the cities and created a better home market. Roads were improved, canals constructed, and later, steamships and railroads further increased transport facilities and made agriculture profitable in areas which formerly were inaccessible. The introduction of turnips and potatoes as field crops about 1725, and the sowing of artificial grasses and clovers were epoch-making events. The growing of root crops made better methods of cultivation necessary; the horse hoe cleaned the dirty land, and the turnip made it possible not only to winter cattle, but to fatten them. Before the introduction of turnips the cattle and horses were fed largely on straw and boiled chaff, and in spring they were often so weak that they had to be carried out of the byres or stables.

The new movement was in full swing by the second half of the eighteenth century, and went on for roughly 100 years. Fields were enclosed, the runrig system and the in-and-out fields disappeared, and a new system of husbandry was adopted. Implements were improved, fertility increased and agriculture entered on an era of prosperity. As land became valuable and rents rose, the reclamation of waste land was undertaken all over the country. In some instances the reclamation was carried out by the big landowners, but more often it was done by the small tenant farmers. They obtained improving leases, by which they paid only nominal rents for the improved land for a period of years. The rigs of land which were already under cultivation were straightened and levelled, and the moorland and waste areas adjoining the farms were drained, trenched and limed. In many districts the area of cultivated land was soon doubled and trebled.

Most of the work was done by hand, and a vast amount of labour was expended in reclaiming this new land. The plough was being improved, but most of the land was too rough and intractable for ploughing and had to be hand trenched. It was a period of feverish

activity—clearing stones, enclosing fields, making drains, trenching and liming. The old houses were improved or rebuilt and better accommodation provided for the stock.

The reclamation in those days had to be carried out without the aid of artificial manures, but the larger stock of animals made possible by the growing of turnips, provided larger supplies of farmyard manure and this was particularly valuable for the newly reclaimed land. Near the coast, seaweed and shell sand were used, and in some places crushed bones were available, but the absence of plentiful supplies of phosphates must have been a severe handicap. This wonderful period of activity and expansion in Scottish agriculture went on with occasional breaks for about a century.

In the second half of last century the vigorous campaign of reclamation gradually slowed down and practically ceased. The slowing down was perhaps partly due to the fact that much of the best and most accessible land was by this time reclaimed, but the economic causes were even more powerful. The opening up of vast tracts of fertile agricultural land in America and elsewhere, coupled with cheap transport by rail and steamship, brought prices down and the great industrial centres demanded cheap food. It was no longer profitable to reclaim land, and the area under cultivation began to decline. Some of the land which had been brought in from the hillsides, moors and heaths with such effort, gradually slipped back to poor pasture and semi-waste.

The possibilities of reclamation and land improvement at the present day deserve consideration, for with the increasing industrial development of other countries, it becomes more and more important for us to grow as much as we can of our foodstuffs, and from social and employment points of view it is desirable to have as many people as possible on the land. With modern developments in motor traction, improvements in implements, fertilizers and crops, we are much better equipped for carrying out reclamation work than our forefathers were, in spite of the fact that labour costs have increased.

Draining is a costly item in reclamation, but on suitable land the tractor has made possible the use of the draining plough, and this effects a considerable saving in labour. For cultivation work there have been very great advances in the way of improved ploughs, disc cultivators and other implements, such as the gyrotiller and cultivators of the rotary type. Rotary cultivators have been used successfully in reclamation work on peat-land in Lewis, and on hill-land in Wales. An implement which is little known in this country is the rotary spade harrow, sometimes referred to as the Finnish harrow or the Swedish harrow. It is employed fairly extensively in

Sweden, Finland and certain parts of Germany and has proved very useful on peat-land at the Macaulay Farm in Lewis.

Successful reclamation at the present day is also assisted by the abundant supplies of artificial fertilizers which are available at relatively low prices. Much of the reclamation work in the past was handicapped because of lack of phosphatic manures, for much of the land reclaimed was particularly deficient in phosphoric acid.

RECENT EXPERIMENTS IN LAND RECLAMATION.

A considerable amount of reclamation work has been carried out in recent years in Holland, Italy, Germany and various other countries but comparatively little has been done in Britain. Experiments on the improvement of hill-land have been carried out in Wales,[1] in the south of Scotland[2] and elsewhere.

In Scotland the improvement of peat-land, which occurs so extensively, has been studied at the Macaulay Institute. An experimental farm has been established on a particularly wet and barren peat moss near Stornoway in the Island of Lewis, and the problems of the reclamation of land of this type are being studied there. The peat at the Macaulay Farm belongs to the Scirpus type of the "Moss" group of peats. Its slimy colloidal nature renders this peat particularly difficult to drain, and, on account of its high acidity and poverty in plant nutrients, it presents very different problems from the fen peat of East Anglia. Part of the Macaulay Farm has been brought under arable cultivation and part of it has been improved as grazing land without cultivation. It has been found posssible to grow good crops and to establish excellent pasture on this poor type of peat. An account of the methods employed has appeared in the *Scottish Journal of Agriculture.*[3]

The methods employed in Lewis have been applied in Newfoundland, where the writer laid down experiments in 1935. An area of almost 40 square miles of virgin land, about half of it mineral soil, covered with timber, and the remainder peat-land, is being converted into an agricultural settlement by men who were unemployed.

A peat-land reclamation experiment is at present being carried out near Carnwath in Lanarkshire, by the Macaulay Institute on behalf of the Commissioner for the Special Areas in Scotland. The work has been undertaken on two mosses comprising 550 acres of peat averaging about 20 feet in depth. The peat belongs to the "Moss" group, but is of a more fibrous and less decomposed type than the Lewis peat, and consequently the peat will be more easily drained. During the summer of 1936 main and lateral drains were opened and in 1937, after shrinkage has taken place, wooden drain

boxes will be laid and the land cultivated. For the excavation of the main ditches a scoop type of excavator, capable of dealing with soft peat, was devised, and for the laterals a draining plough was modified for the purpose and this implement was drawn by a tractor of the caterpillar type. A considerable reduction in draining costs has been secured in this way. Part of the area will be brought under cultivation and part of it improved as grazing land.

Experiments on peat-land have also been carried out in recent years at Lochar Moss, Dumfriesshire,[4] and many farmers such as Mr. A. Allan of Auchenleck, Galloway,[5] and Mr. Hugh Hamilton, W.S. of Cairns Castle, Midlothian, have been gradually reclaiming land which was practically derelict.

The results of these experiments on waste land, both mineral soil and peat, indicate that with modern methods and appliances a great deal of poorly utilized land can be improved at a reasonable cost. The conversion of this to arable land is desirable in certain districts, such as parts of the Highlands and Islands of Scotland, where more land is required for new holdings or the extension of existing holdings. Apart from this, there is room for a vast improvement of great areas of waste and semi-waste land for grazing in many parts of the country.

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THE AGRICULTURE OF THE SOUTH-WEST OF SCOTLAND*

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For purposes of agricultural education, Scotland is divided into three parts—the northern part with Aberdeen as centre, the eastern part with Edinburgh as centre, and the south-west with Glasgow as centre.

The south-western area comprises the counties of Argyll, Bute, Renfrew, Ayr, Dumfries, Kirkcudbright, Wigtown, Lanark, Dumbarton, Stirling and the western half of Perthshire. West Perth is left out of this review. Within this area there are a number of distinct systems of farming practised and the systems range from the most intensive—fruit growing and glass-house culture where four to six people are employed per acre—to the most extensive—hill sheep farming on the poor soils at high altitudes where two or three acres are required to support a sheep and one man only is employed on 1,000 to 2,000 acres. Between these extremes there are many modifications and combinations.

But what might be called the standard system of farming and by far the most important system, is dairying or milk production. The south-west is a dairying area with the exception of the counties of Stirling and North Argyll.

As to why dairying has developed to such a dominating position, there are three chief reasons—the climate, the soil, and the proximity to the populous centres of the Clyde Valley.

The rainfall in this south-western area is fairly heavy and probably averages about 38 to 40 inches. There are specially favoured areas with only 30 inches, while in others the rainfall amounts to 60 inches per annum. The rainfall is quite beyond the optimum for grain growing. Cereals will give a full yield of better quality grain with a rainfall of only 27 or 28 inches, such as is common in the east of Scotland. This ample rainfall and moist conditions, however, ensures succulent pasture, a decided asset in the economical production of milk.

The second reason is that much of the land is not of a sufficiently fertile nature to make the growing of cereals for sale an economic proposition, nor is it good enough for the fattening of cattle on

* Paper read at the July meeting, Glasgow, 1936.

pasture. It is a noteworthy fact that in Scotland much of the best grass-land is devoted to the fattening of cattle and the second-rate land to milk production.

A big proportion of Scotland's population is concentrated in the industrial area around Glasgow and consequently there is a big demand for milk.

Before reviewing in some detail the agriculture of this area it may be well to indicate the relative importance of the agriculture of this area to the whole of Scotland. Of the total acreage of wheat, the south-west has 11 per cent., of barley 14 per cent., oats 22 per cent., potatoes 22 per cent., turnips and swedes 17 per cent., sugar beet just over 1 per cent. Roughly, the south-west can only claim 20 per cent. of the crops grown.

Of the total horse population in Scotland, 28 per cent. is found in this area, of cattle 43 per cent., of sheep 40 per cent., of pigs 38 per cent. Roughly, the south-western area contains 40 per cent. of the live stock.

In the figures of the agricultural output for Scotland, i.e. the products sold off the farm, live stock and live stock products, such as milk accounts, for 81 per cent., the balance of 19 per cent. being crops of some kind. Viewed in this light the south-western area ranks high in the scale of values of agricultural output.

Soils.—All kinds and variations are found. Generally speaking, much of the land in Stirling, Lanark, Renfrew and North Ayrshire is of a heavy nature. A long rotation is followed—the land lies a considerable time in grass, and hay bulks largely in the winter keep for stock. Timothy meadows are common. Further south—South Ayrshire, Dumfries, Kirkcudbright, Wigtown and the Kintyre district of Argyll—the soil is of a lighter nature, a shorter rotation is followed and straw and turnips bulk more largely in the winter keep for stock. But owing to the low price of grain in recent years, there is a tendency to lengthen the rotation by allowing the land to lie an extra year or two in grass, and more hay is now grown for winter keep.

Another modification which is being introduced is to take a green crop—potatoes or turnips—when grass-land is ploughed up. This is to avoid the increasing tendency for lea oats to lodge before harvest which has become very prevalent in recent years as a result of the enrichment of land under pasture due to wild white clover, etc.

Since 1927 the area under wheat has increased by 44 per cent., but barley has decreased by about 25 per cent. With regard to potatoes, Ayrshire has the greatest acreage and it is on the sea-board of that county that the early potato industry has been chiefly

developed, but potatoes are quite an important item in the counties of Lanark, Renfrew and Dumbarton. In the early potato districts, eel-worm is becoming prevalent, due no doubt to taking potatoes too frequently in the rotation.

Saleable Commodities.—As already indicated, milk is by far the most important product. Next to this would come cattle, that is, the combined sales of fat cattle, store cattle, dairy cows. Third in importance sheep could be placed. In some of the counties of this group, particularly Dumfries, it is perhaps the most important. Potatoes, poultry and eggs, fruit and horticultural produce rank about equal, and all of them more important than grain. In the more remote counties of Wigtown, Kirkcudbright, South Ayrshire and the Kintyre district of Argyll, cheese-making was formerly almost universal on dairy farms. In recent years, however, there has been a decided change over to liquid milk which has been one of the chief causes of the "surplus milk" of which so much has been heard in recent years.

Breeds of Live Stock.—It has been already stated that the south-west is a dairying district and the breed which is kept is almost universally the Ayrshire. This breed originated in the county of Ayr. It is hardy and an economical producer of milk, yielding well on second-rate grazings. Scotsmen do not perhaps render quite all the homage that is due to the Ayrshire cow for the outstanding part she has played in the farm economy in the south-west. In these dairying counties there are thousands of acres of second- and third-rate land, much at a high altitude, which has been kept in cultivation and rotation pasture and hay, simply through the Ayrshire cow affording a profitable means of marketing the crops and grass from these farms in the form of milk. In the last sixteen years however—since the war—the great merits of the Ayrshire cow are being recognized in England and there is weekly a substantial cross-border traffic from Scotland of Ayrshire cattle. There are many fine herds of pedigreed milk recorded Ayrshires and between 400 and 500 herds are licensed for the sale of Certified or Grade A (T.T.) Milk. This is approximately 5 per cent. There is a sprinkling of herds of British Friesians somewhere round 8 per cent. of the total. This breed seems to do well on the better classes of land.

Dairy Shorthorn bulls have been used to cross with Ayrshire herds—the male calves being more valuable as stores and the first-cross female proving a good dairy animal. While this is still practised it is on the wane. A noticeable fact in auction marts is that Ayrshire calving heifers or cows fetch higher prices than

Shorthorn crosses. Until recently the reverse was the case. The low price prevailing for fat cows, even good Shorthorn cross cows, is possibly a partial explanation. About the end of the war or soon afterwards, a few herds of Red Polls were started in the south-west of Scotland, but these are now non-existent.

Galloway cattle are found in considerable numbers west of the line from Glasgow to Carlisle. They are hardy and justly popular. The progeny from mating with White Shorthorn bulls is in great demand.

There are occasional herds of pure-bred Aberdeen Angus cattle and also of beef Shorthorns. The largest herd of pedigreed Shorthorns in Britain is found in Wigtownshire, and is owned by Mr. A. J. Marshall who has a whole range of farms stocked with Shorthorns.

Sheep.—Sheep as already mentioned form an important branch in the farm economy of this group of counties, coming third in importance after dairying. The black-faced breed is by far the greatest numerically. With the exception of Dumfries, it is the breed found on all the hills and exposed grazings in Argyll, Lanark, Ayr, etc. Pure-bred flocks are kept on the higher grazings. On lower and better grazings the ewes are mated with Border Leicester rams which give cross or grey-faced lambs—a cross still most popular with butchers despite the very considerable numbers of Suffolk crosses now on the market.

Black-faced draft ewes, after producing their fourth crop of lambs on the hills, i.e., when 5½ years old, are in great demand for crossing purposes on Lowland farms.

The Cheviot breed is found in Dumfriesshire on the green hills which prevail in that county. They are also found in South Lanark. Again, on the lower and better grazings in these districts they are mated with Border Leicester rams to produce what is known as the Half-bred lamb. There is a good demand for the ewes of both these crosses, i.e., cross ewes (the progeny of Border Leicester ram and black-faced ewe) and Half-bred ewes (the Border Leicester × Cheviot). Incidentally, Half-bred ewes are in great demand in the south of England for crossing with Suffolks and South Downs.

There are many small flocks of park sheep on dairy and other farms in the South-west area which are kept for the production of fat lambs. This is a comparatively recent development. In most cases these flocks are extra or additional to the stock formerly carried. With the improvement of pastures due to wild white clover, manuring and management, and also due to the more liberal supply of concentrates fed to dairy cows, it is found that this extra

head of stock can be carried. And with the exception of the two years 1931 and 1932, such sheep have been paying reasonably well.

There are many excellent pure-bred flocks of Black-faces, Cheviots and Border Leicesters.

Sheep husbandry is relatively a much more important branch in Scotland than in England. While in England there are between five and six cattle for every one in Scotland, the sheep ratio is two in England to one in Scotland.

The increase of bracken on hill sheep farms is becoming a serious menace. A committee to investigate means of eradication and control of this pest was set up by the Department of Agriculture for Scotland two years ago.

Pigs.—Relatively the pig industry is not nearly so well developed in Scotland as in England. There is only one pig to about every fifteen in England. Pigs are found in the largest numbers in those areas where by-products are available. Thus Wigtown (where cheese-making prevails) has 19,500 pigs, Ayr 18,500, followed by Kirkcudbright, Dumfries and Lanark in the order named. Many new modern up-to-date piggeries have been erected in recent years capable of accommodating 200 pigs and more.

Horses.—As elsewhere, horses are on the decline. The Clydesdale is the one breed found in this area, unless for Highland ponies or garrons in Argyllshire and Arran. On many of the larger farms two or three foals are reared annually. In recent years this has been quite a remunerative proposition.

Poultry.—The poultry industry is well developed on the small and medium sized dairy farms and is also the mainstay on many smallholdings. In Scotland, Orkney has the highest number of poultry per arable acre. Ayr comes second, Bute third, and Renfrew fourth. A very considerable proportion of revenue on many farms is obtained from poultry. But progress and development is at the moment arrested. In fact, reduction of stocks and even abandonment of poultry-keeping is not unknown. This is due to the increasing incidence of disease.

Horticulture.—This is without the scope of this paper but there is in the south-western area some 9,000 acres under fruit. Lanarkshire leads in all branches except that raspberries and apples occupy a greater area in Perth and Angus. Glass-house culture—tomatoes, etc.—has developed greatly in the last few years. Strawberry cultivation which used to be regarded as the most remunerative branch of fruit farming, is on the decline. This results from the increasing prevalence of strawberry disease.

Changes in Farming Practice.—There is an increase in dairying. What were formerly feeding and stock-rearing farms have in recent years gone in for milk selling. Cheese-making is on the decline. Butter-making is almost a thing of the past unless in a few cases where the product is retailed along with the butter-milk in the nearest town or village, and where the price obtained for the butter-milk makes this economically possible. Rotations are being lengthened by ploughing a smaller break annually and leaving the land a greater number of years in grass.

The farmer in the south-west of Scotland is a skilled, enterprising, hard-working individual. Perhaps environmental conditions have evolved these characteristics. He has had to wrestle with an indifferent climate and in many cases with a second-rate soil. In support of this it may be stated that during the depression in the eighties and nineties of the last century when agriculture had a very difficult time—especially arable farming—farmers from the south-west of Scotland treked east and also south into England, and by their skill and enterprise wrested a living from the soil on farms which were being left derelict. History is repeating itself. During the present depression we again find them going east to the arable farms and south all over England.

THE AYRSHIRE EARLY POTATO INDUSTRY*

By Robert Laird

The growing of early potatoes on the Ayrshire coast has been practised for about 70 years. There are a few fields which have grown potatoes without a break for the whole of this period, but their number is now fast decreasing. There is a tendency, where practicable, towards the adoption of a rotation, even although it may be oats and potatoes. On a few farms (more inland) potatoes, oats, hay is the rotation. The earliest fields, however, are coarse sandy soils, suited for very little else, and only kept productive by catch cropping and by liberal applications of seaweed and farmyard manure along with artificials. Some farms have only a small coastal strip suited for growing potatoes, the back land being too heavy for this crop. A number of desirable potato farms have only very ordinary land behind. Other farms have a much larger proportion of useful land; soils, which though hardly as early, are more of a light loam and are less liable to suffer in a dry season.

The main, in fact, almost the only, variety grown is Epicure. It has a number of defects, bad shape, non-immunity, and high prolificacy; but it can withstand storms, grows a good haulm, and recovers readily from frost. Herald, Arran Crest, Arran Pilot, and Ballydoon have been tested in recent years, but have failed to displace Epicure on the early farms.

Seed is never taken from the early crop, but may be grown on the higher land of the farm or bought in from later districts. The seed crop is lifted in an immature condition, and all except the very largest and very smallest tubers are used for seed. The larger sized tubers are preferred for the earliest fields—the plants therefrom recover best from frost. The smaller size may be used for later fields or for next year's seed. For early land it thus requires 30 cwts. seed per acre and many growers allow the seed to stand in boxes (3½ stones) in the field till well greened. During autumn and winter the boxes are stored in cool, airy, well-lit buildings, the doors being kept open in the day-time except in times of frost.

The land is seldom ploughed till after the turn of the day, because it has usually been sown with Italian rye-grass immediately after the lifting of the potatoes in June, and autumn and winter grazing is afforded cattle and sheep. After it is first grazed down, seaweed or

* Paper read at July meeting, Glasgow, 1936.

farmyard manure is applied and it may again be grazed right up till ploughing. Some of the dung is produced on the farm and the remainder is purchased. The seaweed arriving with the autumn storms is welcomed as it is not accompanied by an invoice. The land is ploughed only once, to a depth of about 10 inches, the dung being put right down.

If the weather is favourable, planting commences in the second week of February; further south, in Wigtownshire, planting often begins in January. The preliminary cultivation consists of a double turn of the harrow as a rule; a combined double driller and manure distributor follows. The drills are invariably 25 inches; the narrower drill enables the plants to meet earlier in the rows and impresses the prospective buyer more favourably. The boxed seed is planted by hand to minimize the risk of breaking the sprouts, and in recent years a dibbling or spacing arrangement has been used on many farms; this may be a separate machine or it may be an attachment behind the driller. The distance between the sets is generally 10–12 inches, and on one farm, at least, sets with broken sprouts are not planted on the earliest fields. The drills are spaded out to within a few feet of the hedge.

Artificial manure is generally employed at the rate of 12–16 cwts. per acre; even 20 cwts. has been applied. Some farmers purchase their manure ready mixed from the merchants; others mix their manure on the farm with the assistance of their women employees during the winter months, the cost of mixing being only a few shillings per ton. One of the common mixed manures purchased shows an analysis of 8 per cent. N, 9 per cent. P_2O_5, and 3 per cent. K_2O. This shows a low potash content, but many of these soils have had for years liberal dressings of seaweed. Many growers now prefer the alternative 7½, 9, 5½. On soils of low potash content, our experiments have shown that equal percentages of nitrogen, phosphoric acid, and potash are best, viz., 7–8 per cent. Such an analysis is given by a mixture of 5 cwts. sulphate of ammonia, 5 cwts. superphosphate, 2 cwts. muriate of potash, and 2 cwts. steamed bone flour or meat guano. Some growers substitute potash salts for muriate, where potash is not so necessary. The I.C.I. concentrate fertilizer has not become popular; the soils are probably too deficient in lime, and in addition the No. 1 is relatively lower in nitrogen than the early "compound" manure. With a 12½, 12½, 15 analysis half the quantity per acre supplied too little nitrogen; recently a No. 9 (15, 15, 9) has been prepared for Ayrshire growers.

In recent times many growers have been liming their potato land, with very good results; increases of well over 50 per cent. were

recorded in our West Kilbride experiments. Soil analyses have shown that most potato soils have a pH of under 5, some are under 4. The lime is often applied after the crop is raised with the Italian rye-grass catch crop. Even where a short rotation is in force, there is a serious danger of lodging if the lime is applied when taking the oat crop. A good lime very rarely causes scab on acid soils.

The tubers are planted directly on the artificial manure, and the drills are split with the drill plough. To minimize the risk of scorching the buds, spreaders or chains are often attached under the manure spouts. The ends are covered by spade. During April, when the potato shoots are coming above ground and the sides of the drills have become covered with small weeds, the saddle-harrow or spider is used. The growers hope that there will be now no severe frosts. If the sprouts are destroyed at this stage the drill plough is used for covering them over and bringing on fresh growth. As a preliminary to hand weeding the grubber is put through the drills; weeding is general early in May.

The second and third weeks of May are the most dangerous times for late frosts. April and June frosts are not so serious. The land which suffers worst and most readily is the flat land away from the sea. Land on a slope towards the sea seldom suffers if the shaws are dry, even when 8 degrees of frost are reported inland. Land too early reached by the sun's rays is at a disadvantage on a frosty morning. Some growers have been known to burn straw and old bags during the night and early morning, so that the smoke might be wafted over the field.

Top-dressing of the potatoes with manure is not practised, at least officially; after frost or where for other reasons the crop has suffered, nitrate may be applied. Cultivations after hand weeding consist of the grubber and drill plough being each used on one or two occasions. The single horse is trained to work with a 4-foot headland.

The earliest fields are ready for lifting early in June. In an early season a start may be made in Wigtownshire before May is out. Ayrshire is generally ready by the second week. The earliest fields are sold privately to merchants; later fields are sold either privately or at special auction sales held at one of the farms. Prices in recent years have ranged from £30 to £60 per acre; the lower figure does not reach costs of production. Lifting is undertaken by the merchant who supplies a squad who raise the crop with the graip (or potato fork) and fill everything of a useful size into 12-stone barrels, which at one time had sometimes to be carted 10 miles to a station. A few farmers raise and market their own crops. The workers are often

Irish and have to be housed at the farms. When crops are poor or demand good, they do not have much time for sleep. Growers do not desire too heavy crops; the cartage work is heavier (the farmer's share of lifting operations) and prices fall badly unless crops are short in other parts of the country.

A second crop naturally follows the early potato crop, as most of the land is cleared early in July in a normal season. Barley is sometimes grown and ripened on the earliest fields, but Italian rye-grass is the commonest crop. In some places cabbage are planted out for spring use, while elsewhere seeds of the cabbage race are sown for sale as transplants in the spring. The general practice is to sow Italian rye-grass broadcast after the diggers and harrow it in. A number of the growers now cart off the shaws.

The main pest of the early grower is the potato eel-worm. Its activities and increase can be controlled to a large extent by carting off the shaws on infected land, planting late and lifting early, and adopting a rotation. Its ravages are intensified by frost, unfavourable weather, and lime deficiency. The 10 cwt. per acre dressings of sulphate of potash recommended by an English investigator have been of no use in controlling eel-worm in Ayrshire. Some recent experiments in the county have, however, indicated another control method, which promises to be effective in reducing the infection.

THE BRACKEN ERADICATION PROBLEM

By Professor K. W. Braid
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What is the bracken problem? Imagine a highland sheep-walk of, say, 4,000 acres, all of which were available for sheep-grazing 40 years ago and of which only 2,000 acres are available to-day. The other 2,000 acres have in these past four decades been invaded by, and are now dominated by, bracken, so that only half the head of sheep can be carried now which was carried then. Nor is this all, for each year sees a progressively rapid advance of the bracken. Again, in living memory, an area round Loch Lomond, which is now all covered with bracken, could not provide all the material which was required for litter purposes.

Bracken does not invade like a wave of water. It is much more subtle in its methods. At first there are only a few fronds with plenty of grass for grazing purposes between, but in a few years the density increases so rapidly that in 6–7 years the bracken canopy may be so impenetrable to light that most of the ground flora dies. Long before that stage is reached sheep have ceased to glean grass in that vicinity. Sheep object to pushing through dense wet bracken in search of food and as a rule avoid it or pass through bracken along definite paths. The exception is when sheep are struck with maggot fly. Then they take cover beneath dense bracken and are lost to the shepherds who could treat them in the majority of cases if they could see the trouble in time. Some farmers consider that it pays to cut the bracken just to simplify the shepherding, for without the bracken a shepherd can survey most of his hirsel from a few vantage points.

The spread of bracken has not been confined to Scotland. Professor Stapledon[14] (p. 74) refers to 14 farms in Merioneth where 600 of 2,997 acres standing between 500–900 feet (20 per cent.) have reverted to bracken.

After the lapse of 12 years or so, this summer I revisited Ashdown Forest in Sussex, and was amazed to see how the bracken had advanced in certain areas. I understand that at Leith Hill in Surrey also the bracken is dominating the heather.

The Spread of Bracken.

Bracken is a primitive plant of world-wide distribution under many types of climates. It is pretty generally spread throughout Britain, but is more abundant and robust in the moister west than

in the east. It presumably was originally a woodland plant, but thrives perfectly well in the open in northern and western parts. Personally, I have a suspicion that its invasion of the non-shaded areas is connected with the milder winters and less desiccating summers which we have enjoyed, for the severe winter of 1917, according to Professor Holbourn, practically exterminated the bracken on his island of Foula off the Shetlands. In Finland, with its continental winter, I understand it is confined to the sheltered and better drained woodland regions. In the extreme north—in the Shetlands—bracken is noticeably susceptible to the severe winds and is only found in wind-sheltered pockets on the west, and nowhere as far as I have seen grows very tall or luxuriantly. It is larger, however, than the herbarium material of St. Kilda bracken which I have examined. In the north of Scotland it is still small material of about two feet in height and by no means rampant in northern Caithness and Sutherland. When one comes into the more sheltered parts of Southern Sutherland and Ross-shire one begins to meet higher bracken of considerable density, which possibly reaches a maximum in Argyllshire and West Perthshire.

Generally in the east the bracken is smaller and less dense than on the west, and south of the Lake District (except in Wales) the growth is as a rule shorter and less dense, except in woods. Bracken likes good deep soils, but it can grow on shallow soils. On the better soils it may reach a height of 5–7 feet. I have never seen it in Scotland 10–14 feet high sprawling into light through the copse or small trees as one sometimes sees it in Surrey, Sussex and Hants. This, I think, is only possible where the intensity of the light is great, for this seems to occur where the birches have sufficient light to grow congested.

Fenton[7] and various authors[3, 6, 8] have shown that recent spread has in part been due to the replacement of cattle by sheep, to the cessation of bracken being used for thatching, litter, etc. The "bracken bush" referred to in the "Ballad of Otterburn" differs from all other "bushes" in possessing the bulk of its branches underground.

In sandy dunes or in bracken-infested saw-dust pits one can disentangle the underground stems by the yard, and it is then seen that the extensive subterranean stem of a considerable patch may all belong to one plant. Small bracken patches certainly consist of single plants. As will be seen presently, in larger groups the death of the centres may lead to many individuals, but I believe that we can get single vigorous plants covering an acre or more. In other words, bracken may be one of the largest plants known.

In deep, friable soil the underground rhizome consists of three or more zones of more or less horizontal stem. The lowest—about 20 inches beneath the surface of the soil—consists of the main exploring system which may extend up to a yard or so per year. From this, arise alternate branches which spread sideways and take up a more intermediate position 9 inches or so beneath the surface of the soil. These also bear alternate branches which reach upwards to within a few inches of the surface before tending into the horizontal position. These latter branches usually make very small annual growths in length, but bear many fronds. These are seldom borne from the deepest rhizome zones, but may be quite abundant on the intermediate one.

In shallow soil the whole of these zones may be compressed into nine inches. The terminal bud in all cases gives rise to one and sometimes two side-buds, which develop into side-branches or fronds, while the terminal portion continues the growth outwards. Sometimes these lateral buds do not develop but remain dormant. When they do grow into fronds, quite frequently a bud forms at their base, which may ultimately mature into a frond or remain dormant. The end of a frond-bearing branch in late autumn will show the growing point with its lateral bud and further back a well-formed frond-bud an inch or two high. This is the destined frond for the following spring and the lateral bud the one normally destined for the spring succeeding that. If for any reason the older bud is destroyed the younger one is forced into development that year. In addition, dormant buds, which would remain dormant, are activated into growth. Frond development is often more free from the short, uppermost frond-bearing branches. In many parts bracken may be seen as a weed in arable fields and in this case owes its survival to its deep rhizome and practically all the fronds arise from the perennating rhizome beneath the level of cultivation.

The Destruction of Bracken.

The amount of rhizome may be enormous, 5, 10 or more feet beneath each square foot of surface. Hendrick[12] has calculated 40 tons per acre. This can in great part be regarded as the invested capital of the plant and all methods of extermination based on exhausting the plant of its reserves must take this into account. Recognizing that the fronds build up the carbohydrate food reserve, the chief mode of attack has been to remove the fronds, as not only does this inhibit the production of further food, but the underground reserves are depleted in the efforts at fresh frond development. Theoretically, the best time to destroy the fronds is when they are

practically completely unfolded and have not yet started to contribute food to the reserves. Thus their removal means a complete loss to the plant. Even so, they will require to be destroyed twice or three times per year for one or two years and once annually for a further period of two to five years—say from six to ten destructions. This obviously costs money, and with land at 2s. 6d. per acre (or less) the economics of the subject do not look very promising.

The most simple method of destroying bracken fronds is by the use of the scythe, sickle or stiff wire on a stick, depending upon the density of the frond. Obviously, in a large area the work has to begin before the optimum period and extend past it, but the cost is considerable. Home[13] gives authenticated figures for the cost in South-east Scotland, where the bracken is not particularly dense or wages high, as from 2s. 9d. to 3s. 6d. per cut per acre. In Dumbartonshire, for a first cut these figures could be doubled in many cases. The only objection to the scythe is its cost and its slowness, one to three acres per day according to density and nature of ground.

In order to discover what possibilities there were to decrease these costs and speed up bracken destruction, some years ago the Department of Agriculture for Scotland appointed a small committee of which Principal Paterson is convener to investigate the capabilities of machines designed for the eradication of bracken. I wish to thank him for permission to talk about machines from facts largely learned as a member of the committee, but I accept full responsibility for my interpretations of their behaviour, which are my own and not necessarily the findings of the committee. Moreover, any day a more satisfactory machine might demand trial. In addition I do not forget my own lessons with the harrow. From experiments one year I formed a high regard for the ease and speed with which a chain harrow broke off young fronds in the curled stage. Experiments last year when the fronds were late, thin and very wiry were, however, a complete failure. It is clear that for successful work with the harrow fronds must be young, fat and brittle.

Motor-driven Machines.—Of motor-driven cutting machines we have three examples, the "Collins," the "Allan" and the "Gordon." The "Collins" Junior Power Bracken Cutter has been on the market for some years and many hundreds of acres have been cut by means of it. The 350 c.c., S.V., J.A.P. engine is suspended between two motor-tyred side-wheels and a third "wheel" is formed by a hemisphere in front which rides on the soil, and is rotated horizontally by the engine. This hemisphere carries on the upper flat portion two revolving cutters which are hinged so that they collapse if they hit any obstruction, and re-extend to 6 feet with the centrifugal force.

These slash through the bracken stems at 3 to 4 inches above the surface of the soil. A special machine is made with a round-nosed skid which carries the cutters above and can be used for cutting bracken over heather or rough grass. The controls and steering are worked from the posterior handles. There are three speeds—low gear for hills and heavy bracken, second for general work, and top for moving from place to place or for working in light bracken. The machine costs £75 and can accomplish about 9 acres per day contouring the gradients. It will ascend banks of nearly 45° and will go practically anywhere where a man can walk, except over very stony ground. A draining plough can be used in place of the cutters.

To get the full benefit of such a machine over the short season available (mid-June to end of August) the machine should be run in two relays per day. In this way more than 1,000 acres can be cut per season and the costs work out at about 1s. 6d. per acre or less. While on test the machine has cut half an acre in 16 minutes, but it is improbable that a man will stand up to more than 9 acres per day and the advantages of cutting before mid-June or after August have still to be demonstrated. One of the great benefits of this machine is the manner in which the bracken withers up after it is cut. This allows for the rapid development of the grass.

The "Allan" motor scythe is propelled by a 1½ h.p. 147 c.c. "Villiers" engine which is mounted between the two rubber-tyred road wheels and carries a knife-bar in front and the steering handles with controls behind. The knife-bar slides over the surface of the soil and possesses a movable knife like a reaper, except that it is supported and operated from the middle of the blade. The whole is balanced so that it can easily be tilted over obstructions. For cutting rushes, grass verges, etc., it is fitted with a 3-foot knife-bar, but a wider one (5 feet) is available for bracken. It is light to operate, but has not been extensively tested on bracken areas. With the 3-foot bar it is obviously too slow, necessitating a walk of 2¾ miles per acre, and, say, 3–4 acres per day. Even at £47 10s. and covering 500 acres in the 10 cutting weeks by working in two relays it is unlikely that it would work out at less than 2s. to 2s. 6d. per acre. For the small landowner this machine apparently has possibilities, but it is too soon to report on it.

Messrs. Gordon, of Castle Douglas have put a similar type of bracken cutter of larger dimension on the market, but I have not yet had the opportunity of inspecting this working.

For old cultivated areas which have become invaded by bracken Stapledon has noted the value of the "Hercules" mower drawn by

tractor or horses. A useful Welsh horse-machine is the "Glaslyn" bracken cutter invented by Mr. Pugh. At first sight this looks like an ordinary land roller, but the roller is replaced by knives set parallel to the axle and the machine bumps off one knife-edge on to the next. The knives are in two sets of seven, each revolving independently, and the axle is keyed to a heavy rectangular frame which rides above the rollers. Chains are attached to this frame and during haulage the frame rides horizontally. On release of the traction the front of the frame tilts downwards and on hills can act as a sprag. The machine can be drawn from either side and is provided with shafts and wheels for road transport. Between the knives there are small steel bars to depress small bracken. The bracken is "rolled out" and partially cut at 8-inch intervals. The depth of the cut depends on the type of land. On mossy grass the bump is diminished and the cutting effect reduced. The machine costs £18 10s. and can cover about an acre an hour; if the slopes are contoured steep slopes can be negotiated. Stony ground naturally blunts the 14 carbon steel knives which in this case require to be sharpened. Generally, the knives stand up well to the work and except when the bracken is cut too late (a "first cut" in late July) the fronds quickly wither. The machine is quicker with a large pony than a horse and one can expect one machine to cover about 400 acres in ten weeks at a cost of about 2s. per acre.

Other Machines.—Two other machines are deserving of mention. Mr. Stanley Bligh in South Wales uses with success a heavy oak trunk with flattened sides as a "roller," and Capt. V. H. Holt has designed a 4-inch square, solid iron bar which rotates from terminal axles—the "Holt" bracken bruiser. The bars are only 4 feet or so long, but if circumstances permit, more than one can be dragged at a time. Reports on both machines are satisfactory.

The "Collins" motor bracken cutter and the horse-drawn "Glaslyn" were satisfactorily reported on last year by the bracken committee and the Department of Agriculture for Scotland this year offered to pay half the cost price spread over three years, where a reasonable use of the machines was made. When one realises the economy and speed of the operations compared with scythe cutting it is understandable why the latter was not included in the scheme.

After a few years of cutting the height of the fronds become less and they are spaced further apart. The natural temptation is to cease cutting at this point as the bracken is no longer dominant, but a lapse of two years from cutting means that the area will revert to the bracken-dominated condition and all previous labour and expenditure are wasted. What is urgently required is therefore a

"mopping-up" machine which will cover a wider stretch at a time. No satisfactory machine has been approved for this purpose, but I believe that modifications of the "Crossley" motor-drawn cutter and the "McCubbin" machine may be useful for this purpose.

The "Crossley" cutter (£10) consists of a 6 feet wide metal "V" on skids with the cutting edge towards the outside of the "V." Pulled rapidly, by means of an old car, it severs the stems of bracken, thistles, etc. The "McCubbin" machine (approximately £15) at present is a hand-pushed machine. It is about 5–6 feet wide and made up of a series of aluminium "V's" in the acute angles of which are razor steel cutters. The whole is attached to a light frame for hand pushing, but the speed, and hence the economy of operation, is not greater than that of the scythe. The effectiveness of machines of these types drawn in echelon has yet to be demonstrated.

Weed Killers.—Weed killers which will kill bracken at one operation are economically prohibitive. Of these, sodium chlorate at 33s. to 35s. per cwt. is probably best. On sandy soils an application of 2 cwts. per acre applied dry in late June is wonderfully effective, but the total cost is approximately £4 per acre. On more peaty soils an application of more than 2 cwts. is necessary. In addition to the cost the destruction of the grass is a great disadvantage. By yearly cuttings the grass becomes better each year and it is obvious that combined with manurial treatment a still geater improvement could be effected.

Much bracken lies in inaccessible places, and along old boundary walls it forms a dangerous source of fresh invasion. Principal Paterson has therefore initiated a series of experiments utilizing liquid or dry "sprays." In 1934, experiments were conducted with an autogyro using 10 per cent. sulphuric acid, but weather conditions were far from favourable. In this case a base had to be used about 5 miles from the area to be sprayed and climatic conditions did not allow the machine to fly sufficiently low. More effective treatments have been carried out by means of a 100-gallons sprayer, containing 10 per cent. sulphuric acid, drawn by a tractor. While the acid has not a severe action on the grass the scorched bracken remains for a long time and inhibits grass development. It demands a good water supply, requires a large staff of workers (4 per machine), and even although it accomplishes more than an acre an hour I see no hope of it working out at less than 7s. per acre, or ten treatments over 6 years for complete eradication, costing at least £3 10s., against approximately £1 for the "Collins" or "Glaslyn." In my opinion at present, cutting has it in 99 cases out of each 100 in preference to sprays, wet or dry.

Advertisers of various machines stress the advantages of a bruising wound over a clean cut one. They do so, I consider, on a false assumption. In my opinion, a clean cut wound bleeds more than a torn wound; just as a clean cut human wound bleeds more than a mangled wound. Young juicy bracken bleeds freely; if there is adequate soil moisture, and, if the wounded end is kept moist, continues to exude sap for about a week, raising a column to about 10 inches in a 3-m.m. tube. Later in the season—late July—just before the hardening of the stem commences, the juice is rich in silica which forms a distinct covering to the cut stem. I am indebted to Dr. Jack for making the analysis and Mr. John Wilson for the observation and the material.

In order to determine the effects of cutting on bracken development one may take observations with the ordinary yard grid, but the "Collins" folding square foot grid is handier for the field as it is so light. The total height of the bracken is possibly an even better indication of the vigour, especially if taken in conjunction with the diameter of the stems. In winter, an estimation can be made by digging holes of a definite size, such as one yard square, to a depth to include all the rhizomes and make a comparison of their respective weights. In bracken which is suffering from the effects of cutting, the rhizomes feel flabby instead of turgid, the current year's growths are reduced and often an extraordinary number of small buds are visible.

Biological Control.—In 1927, undoubted fungoid attacks were noticeable on the bracken. These have been described elsewhere ([1,2,4,9]) so that I do not need to enumerate them in detail. In some cases "V"-shaped bracken areas showed the spread of infection from certain loci, but many of the attacks failed to develop in succeeding years. In some places considerable patches of bracken died down rapidly, the rhizomes were affected and the areas became free from bracken, and have remained free except for secondary peripheral advances.

In woodland areas a definite disease, which has been studied by Dr. Mary Gregor ([9,10,11]) and shown to be *Corticium anceps* Gregor, first noted by Bresadola and Sydow in Germany in 1912, is definitely pathogenic. There is a record for Hillsborough near Belfast; Mrs. Gregor has seen it near Dunoon, and I have seen it in woods near Banff, near Crieff, north of Oban, in Dumbartonshire and in the New Forest. In this case small pustules are formed on the underside of the fronds, which look white and powdery and the pinnæ rapidly become eaten away. In the autumn darker sclerotia are formed. It is a disease of the shade and favours damp sites and develops most in wet weather.

Mrs. Alcock,[1] Miss Barnett[2] and others worked on the disease found in the open, but so far no definite pathogen has been isolated, and I am suspicious that the trouble is due to a facultative parasite which only attacks bracken in an unhealthy condition, because in areas which we drained the disease ceased. In this type of disease small pycnidia are visible with a lens on the upper side of the browned frond margins. The stems may be spotted and the frond is asymmetric and distorted. A "thorn disease" consisting of small thorn-like outgrowths from the stem is common, but apparently it does little harm. Unfortunately, bracken is particularly resistant to insect and fungoid pests; but it is interesting to note that dodder, *Cuscuta epithymum* on *Calluna vulgaris*, in the south of England, passes to the adjacent bracken.

REPRODUCTION BY SPORES.

Bracken generally reproduces asexually, but each year many of the plants in each locality produce spores. Sporing is local. In some patches practically all the fronds produce spores while adjacent patches are barren. The barren fronds remain greener late into autumn, while the fertile ones turn brown early. In this way in autumn the fertile and barren bracken can be recognized from a distance. As cut bracken usually produces sterile fronds—at least in the shorter season in Scotland—this point has to be recognized in order to understand why such bracken does not colour so early.

Spores are produced in great quantities and young bracken sporelings have been found in such unlikely places as on the Tower of London,[6] down a water-culvert entrance in the Green Park, London, and many other sites. They do not often occur, but botanists with trained eyes do meet with them occasionally. They cannot be seen every year ; they are distinctly seasonal.

In an investigation into the life-history of bracken, experiments have been carried out to observe the development of bracken from the spore. It is found that in Scotland the viability of spores varies considerably from year to year. For instance, 1934 was a better year for their development than 1935, but any year, under suitable conditions of harvesting and germination, a crop of prothalli can be produced on suitable media such as sterilized soil, peats, tiles or Knop's solution made firm with agar. The prothalli are frequently large, about the size of a threepenny piece, and rapidly produce fronds. The first few fronds have proved difficult for systematists in the field, and have often been confused with the maidenhair fern,[6] but the sixth or seventh frond shows the spacing of the bracken and each later frond becomes more bracken-like. About this stage a

small 2–3 branched rhizome arises which grows horizontally for an inch or two throwing up fronds, but, becoming definitely positively geotropic, begins to burrow into the soil.

Observations to date suggest that these few months are the critical stages for the prothallus. While the spores germinate throughout the year, the maximum crop appears in February–March and the two great enemies are desiccation in the drying winds of March, or late frosts. Apparently, once the rhizomes have penetrated the soil the risks are less, but for the first year the plant is at the mercy of the weather.

At one time I was of the opinion that bracken development from the spore was exceptional, because after years of search I had never seen baby bracken plants in the open or met many people who had done so. I am now definitely of the opinion that at certain periods, given the right type of weather over one or two years, they do occur. If one sits on the side of some of our Argyllshire hills and views the opposite valleys, one is struck by the huge number of small bracken patches which border the banks of streams. It is unbelievable that these are all remnants left from a huge bracken area which had been dominated by forest and in greater parts suppressed. It is much more likely that these represent separate colonies. The secret of rapid spread by vegetative means lies in the number of bracken patches and not in their size. For example, 40 patches of bracken one-fortieth of an acre in extent by an advance of one yard on all sides would cover 1,400 square yards in one year, say, over one-third of an acre; while a patch of an acre in extent would by a similar peripheral advance only increase to the extent of about 480 square yards or one-tenth of an acre, i.e., only one-third as much.

My own hypothesis of the recent bracken spread therefore is, that within the last 40–50 years there were seasons suitable for the development of bracken sporelings and these were produced in huge quantities in many parts. Professor Lang tells me that Dr. Kidson and he saw such an area in Flanders Moss, Stirlingshire. Owing to a series of mild winters these have been able to colonize all sorts of types and depths of soil, many of which would have proved fatal during a series of severe winters. The rapidity of the bracken spread has been due to the multitude of small bracken areas so formed and the sequel is now obvious in many bracken patches in Scotland and North England.

This is the dying out of the centres of those patches on too shallow soils or on too moist soils or on other soils with inhibiting factors. The actual executioner is a fungus of some sort and the result is that from one patch many fragments are formed, of which

some invade suitable areas and others succumb. In many plants which reproduce largely by vegetative means, seed production apparently is the exception and the plant tends more and more to vegetative reproduction. In bracken, however, I think we have a case where spore production and vegetative reproduction are truly complementary, the one seizing special types of climatic conditions and the other suited to the more normal, less favourable conditions.

The problem of bracken control therefore consists of, firstly, exterminating bracken by the cheapest means, which, at present, is the continuous destruction of the fronds by mechanical means, and, secondly, remembering that inaccessible bracken is a possible source of fresh invasion. Subsequent spot treatment of small areas, probably by means of a herbicide, should therefore be looked upon as a possible necessity in areas which have been freed from bracken.

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MASTITIS MILK IN CHEESE-MAKING*

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Systematic testing of the milk of individual cows in dairy herds, and of farm milk supplied to local creameries and milk depots has shown that mastitis is of widespread occurrence and is on the increase in South-west Scotland. On farms and in dairy factories where cheese is made, the presence in the cheese-milk of the produce of mastitis-infected cows is responsible for certain technical difficulties in the process of manufacture and for specific defects in the quality of the ripe cheese.

The detection and exclusion of such infected milk is not always easy of accomplishment. Because of the absence of definite clinical symptoms and of the unchanged physical appearance of the milk at the onset of the disease, mastitis infections in hitherto healthy herds may not be recognized or even suspected. The only suggestive features at this stage are a somewhat heavy odour in the fresh milk, a decline in the milk yield, and a diminution in that sweet attractive flavour which one associates with the normal milk of healthy cows. Yet such milk may be a real source of trouble in cheese-making; its unsuitability for technical purposes arises from two main causes; (*a*) an alteration in the chemical structure and reaction of the milk; (*b*) the presence in the milk of a substance opposing the lactic acid fermentation. The first factor results in a weak unsatisfactory curd, and in a cured cheese which is defective in body and texture, and not infrequently in flavour; the second factor results in slow working during the manufacturing process.

The degree of alteration in the chemical components of the milk is dependent on the stage of infection and the severity of the disease. In general, when the malady has become well established in the milk gland, there is some reduction in the solids-not-fat, in the casein, lactose, and phosphates of calcium; a definite diminution in the citric acid; an increase in the albumin, globulin, and the non-protein nitrogen, and usually in the chloride. In advanced stages of infection, the diminution in the milk sugar and the high chloride content combine to give the milk a salty taste.

One of the distinguishing features of mastitis-infected milk is its reaction to rennet. When normal amounts of rennet are added, the coagulum forms slowly and is soft and fragile, characteristics which have been attributed to some alteration in the casein complex and to the effect of the globulin which, acting as a colloid

* Paper read at the July meeting, Glasgow, 1936.

protector, delays rennet action. The emerging whey is white in colour and contains a higher than normal amount of butter-fat.

A weak rennet coagulation in cheese-making almost invariably results in a cheese curd of poor physical properties and in a mature cheese which is deficient in body and texture. Indeed, it is true to say that a good renneting (coagulation) is the basis of all successful cheese-making. Because mastitis milk so frequently produces a weak coagulum, a precision rennet coagulation test may help to distinguish normal from infected milk. For example, when reference was made to the milk of individual cows in a herd in which mastitis was operative, it was found that, on the average, the milk of the infected animals (27 in number) took thrice as long to coagulate with rennet as that of the healthy cows (8 in number). In the course of these investigations, samples of milk from infected cows have been encountered which, while appearing physically normal, failed to coagulate with rennet even after several hours holding at a favourable temperature.

The titratable acidity of the milk of cows in the more advanced stages of infection is usually lower than that of normal milk. However, the acidity of milk which exhibits the weak coagulating properties already noted is not always low; some mastitis-infected milks may have a normal titratable acidity and yet on renneting produce weak curds which work badly in cheese-making.

From the viewpoint of the practical cheese-maker, a highly undesirable feature of mastitis milk is the powerful restraining influence it so frequently exerts on the lactic acid fermentation. Sometimes the cheese-making process is suspended for hours at a time through lack of acidity development. Such delay in acid formation in cheese-making has been observed even when the infected milk is greatly diluted with the normal milk of healthy animals.

This arrestment is clearly exemplified by reference to the rate of acid formation in a typical mastitis milk and in normal milk. When an active pure culture starter at the rate of 1 per cent. was added to a sample of infected milk, the acidity reached at the end of 6½ hours' incubation at 86° F. was 0·21 per cent.; under similar conditions, the acidity developed in normal milk was 0·61 per cent. Results of the same order have been obtained in a large number of cases.

Experience has shown that starter cultures grown in infected milk of this category rapidly lose their vigour and their ability to rapidly ferment normal milk.

In order to determine more exactly the effect on cheese-making of mastitis milk from cows in varying stages of the disease, parallel

trials have been carried out under controlled conditions with the bulked milk of normal and of infected cows in the same herd. Cheeses of commercial size were made. It may be remarked that while diagnostic laboratory tests had indicated clearly which cows were infected, in no case did the mastitis milk used in these trials show any sign of physical alteration.

With the normal milk, the process of manufacture proceeded smoothly and there was no hold-up of the acid formation at any of the successive stages in the making process. The curds were of excellent body, uniformly firm and elastic, and had a bright and glistening appearance. The average duration of the technical process was 6½ hours, and the cheeses on curing were of first-class quality.

On the other hand, the milk of the mastitis-infected animals behaved very irregularly during the process of manufacture; a longer "ripening" period after the addition of the starter was required to reach the renneting stage (generally more than one hour in excess of that demanded by normal milk); the coagulation was definitely weaker, and there was an increased loss of fat in the cheese whey; the curd after cutting required prolonged stirring before it was fit for pitching; the stage of drawing the whey was also delayed; during cheddaring acid formation developed slowly, and the curd when finally put to the press, usually after 8½ hours, had a relatively low press acidity—frequently below 0·45 per cent. Throughout the manufacturing process, the curds from the mastitis milks had a heavy weedy odour, and the colour was dull and lustreless; the curd at pressing was invariably weak, and on occasion so soft that under pressure it filled the pores of the enveloping cheese cloth so completely that when attempts were made to remove the cloth after the first stages of pressing, the tearing of the rind could not be avoided. The cheeses after pressing and throughout the curing period remained soft and weak in character, and from the market standard would have been assigned a low grade.

When the cheese-making properties of the milk of individual cows were assessed, the features which distinguish normal from normal from infected milk were even more pronounced. (In these experiments of which a large number have now been made, specially designed small-scale equipment was used which allowed of large-scale operations being exactly duplicated and accurate temperature control maintained.) Even when as occasionally happened, the time of manufacture fell within normal limits, the curd characteristics of mastitis-infected milk were invariably defective. Apart from the strong disagreeable odour patent throughout the manufacturing process, the curds lacked firmness and elasticity. In

some instances, the cheese curd was so soft as to approximate suet in consistency; under pressure the mushy curd exuded past the follower of the cheese hoop, and to secure a cheese which would retain its shape when removed to the curing room, continuous pressure had to be applied for 5 days.

Occasionally a cow which exhibits symptoms of mastitis in one lactation may recover and yield apparently normal milk in the next lactation. Frequently, however, such milk has defective cheese-making properties. In the course of these investigations, cheese-making trials were carried out with the milk of one cow which in 1934 had a definite mastitis infection. In the succeeding lactation (1935) this cow yielded milk of apparently normal composition; it was slightly acid in reaction, had a normal catalase index, contained approximately 200,000 leucocytes per ml.; did not reduce methylene blue in 7 hours, and remained liquid after 24 hours' incubation at 37° F. The fresh milk, however, had a somewhat heavy odour, and the incubated sample revealed the presence of long chains of streptococci. It seems probable that this cow was in the "carrier" state. When the milk of this cow was made into cheese, the process of manufacture occupied normal time; there was no holding-up effect, and the acidity at pressing was 0·86 per cent. But the curd throughout the manufacturing process was extremely weak; it had scarcely any body and was so soft that the initial pressure of the screw caused it to squelch from the chessit. Prolonged pressure in the hoop had to be maintained to enable the cheese to subsequently retain its shape. During curing the cheese developed a rough uneven rind, and a brittle sandy texture. The flavour was displeasing.

This and other observed cases of a parallel nature would seem to indicate that a cow which has suffered from a mastitis infection, and has made a "recovery" may produce milk in subsequent lactations which is unsatisfactory from a cheese-making standpoint.

When a cheese-maker experiences a consistent difficulty in the technique of manufacture, either because of slow acid development or because of a definite weakness in the raw curd or in the texture of the mature cheese, he should ascertain whether a mastitis infection is not operative in some of the cows whose milk he is using for cheese-making. In a previous communication on "Arrested Lactic Acid Fermentation in Cheese-making," the author quotes instances where the inclusion of even small amounts of mastitis-infected milk in the cheese-vat resulted in an almost complete suspension of the desired lactic acid development for hours at a time; he also noted that when the offending milk was excluded, the cheese-making process proceeded normally, and good curds were obtained.

CACAO SHELL AS A FOODSTUFF FOR CATTLE*

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Cacao shell is the name given to the testa of the seeds or "beans" of the cacao tree. It is a by-product from the manufacture of cocoa and chocolate, the remainder of the bean other than the shell being used for these products.

The beans, some forty of which are contained in a large pod, are covered with a mucilaginous pulp. In the preparation of the beans for market they are generally placed in a box, or in a conical heap covered with plantain leaves. After fermentation for about six days, during which the temperature rises, the beans are spread out to dry in the tropical sun of the Gold Coast, or other country of origin. At least six days are required for this process.

Knapp and Coward[1] have investigated this process and have shown that during fermentation, yeast containing ergosterol develops in the pulp on the shell, and that during drying in the tropical sun the ergosterol is converted into vitamin D. If the process outlined above is used the vitamin D potency is very high, more than thirty times the potency of summer butter. If, however, the beans are dried in the dark, no vitamin D is formed; it is also much less if the beans are only slightly fermented before sun drying.

It was this high value in vitamin D which first interested us in this by-product of the chocolate industry. Before describing the results of our feeding experiments it will be well to compare the analysis of the cacao shell we used (A, Table 1) with an analysis

TABLE I.

ANALYSIS OF SAMPLE OF CACAO SHELL USED IN FEEDING TESTS COMPARED WITH FOODSTUFFS OF SOMEWHAT SIMILAR COMPOSITION.

	Cacao shell. A. %	Cacao shell. B. %	Good quality meadow hay. %	Dried brewers' grains. %	Broad bran. %
Dry matter ..	95·45	89·1	84·0	89·7	87·0
Protein	16·07	14·5	13·5	18·3	14·7
Fat	4·62	3·1	3·0	6·4	4·0
Carbohydrates	47·56	46·5	40·5	45·9	52·1
Crude fibre ..	18·23	18·3	19·3	15·2	10·3
Ash	7·92	6·7	7·7	3·9	5·9
Theobromine ..	1·03	—	—	—	—

* Based on a paper read at the July meeting, Glasgow, 1936.

of shell (B, Table 1) and of other foodstuffs of somewhat similar composition, using figures taken from Bulletin 48 of the Ministry of Agriculture.

While recognizing the food value of cacao shell as somewhat better than very good meadow hay, we do not wish to dwell on these recognized values but rather to raise the question of additional values, and to invite discussion as to how far these can be admitted in practical agriculture.

The first part of our experiment has been published by Kon and Henry.[2] In the summary of this paper it is stated that:—

(1) Cacao shell . . . was found in curative and protective experiments on rats to contain 35 international units of vitamin D per gram.

(2) The feeding of two Shorthorn cows under winter stall feeding conditions with 2 lb. of cacao shell daily for a month (equivalent to 32,000 international units of vitamin D daily), resulted in increasing the vitamin D content of their butter (and milk), from the winter to the summer level.

The present paper deals with another aspect of this investigation, hitherto unpublished, viz. the effect of feeding the cacao shell on the yield, fat percentage and solids-not-fat percentage of the milk of these cows. It also reports the results of a further experiment. The details of the first experiment are as follows:–

Experimental.

On 3rd January, 1935, four Shorthorn cows of the Institute herd were available. The following cows were placed in the order of calving as control and experimental:—

Rosebud, calved her ninth calf on 10th May, 1934, used as a control.

Flora XIII, calved her third calf on 12th August, 1934, received cacao shell.

Flora XXV, calved her first calf on 3rd October, 1934, used as a control.

Cora II, calved her second calf on 2nd November, 1934, received cacao shell.

All four cows were kept in the same cow-byre; they were not allowed out to grass. From 8th January, 1935, all cows received the following mixture of concentrates, called mixture C: 3 parts dried grains, 2 parts maize germ cake, 1 part soya bean meal. In addition, each cow was given daily:—2 lb. hominy chop, 7 lb. hay, 45 lb. mangels.

On 8th February, Flora XIII and Cora II were given ½ lb. of cacao shell, rising to 1 lb. on 9th February, 1½ lb. on 12th February, and 2 lb. on 13th February. The feeding of the shell was continued at 2 lb. daily till 17th March.

The cacao shell was taken into account when calculating the amount of concentrates fed daily to each cow according to her milk yield, as is usual in our dairy herd. Thus Table II shows the actual amounts of food fed to each cow:—

TABLE II.

Date.		Rosebud. Control.	Flora XIII. Cacao shell.	Flora XXV. Control.	Cora II. Cacao shell.
Jan.	8.	10 lb. C.	8 lb. C.	8 lb. C.	10 lb. C.
Feb.	8.	"	" + ½ lb. shell	"	" + ½ lb. shell
"	9.	"	" + 1 lb. "	"	" + 1 lb. "
"	10.	9 lb C.	7 lb. C. "	"	8 lb. C. + 1 lb. shell
"	12.	"	" + 1½ lb. "	"	" + 1½ lb. shell
"	13.	"	" + 2 lb. "	"	" + 2 lb. "
"	24.	"	" "	7 " C.	7 lb. + 2 lb. "
Mar.	12.	8 " C.	6 lb. C + 2 lb. shell	6 "	6 lb. + 2 lb. "
"	17.	"	Shell discontinued.	"	Shell discontinued.
"	26.	"	6 lb. C	5 lb. C.	5 lb. C.
"	30.	8 lb. C. (no hominy chop)	5 lb. C. (no hominy chop)	5 lb. C. (no hominy chop)	5 lb. C. (no hominy chop)

The cows were thus accustomed gradually to the material, fed in the coarse flaky form in which it occurs in commerce. No trouble was experienced in feeding it and no scouring or adverse symptoms were observed during the period over which it was fed. On 17th March the feeding of shell was discontinued.

The milk was weighed at each milking, night and morning (7 a.m. and 4 p.m.), and having been mixed by pouring from one pail to another was sampled for analysis. In the laboratory the fat was determined by the Gerber method and the total solids were estimated gravimetrically.

TABLE III.

AVERAGE PERCENTAGE OF FAT FOR THREE PERIODS (see Table II).

Cow.		Jan. 3rd to Feb. 7th.	Feb. 7th to Mar. 17th. Experimental period.	March 18th to Apr. 1st.
Rosebud ..	Contol	3·80	3·75	3·75
Flora XIII ..	Shell fed	4·24	4·57	4·23
Flora XXV ..	Control	4·67	4·49	4·85
Cora II ..	Shell fed	3·56	3·99	3·66

The average percentage of fat shown in Table III clearly indicates a rise for the experimental period when cacao shell was fed as compared with the periods both before and after feeding shell to the cows Flora XIII and Cora II, whereas in the milk of the control animals Rosebud and Flora XXV there is a slight fall over the same period.

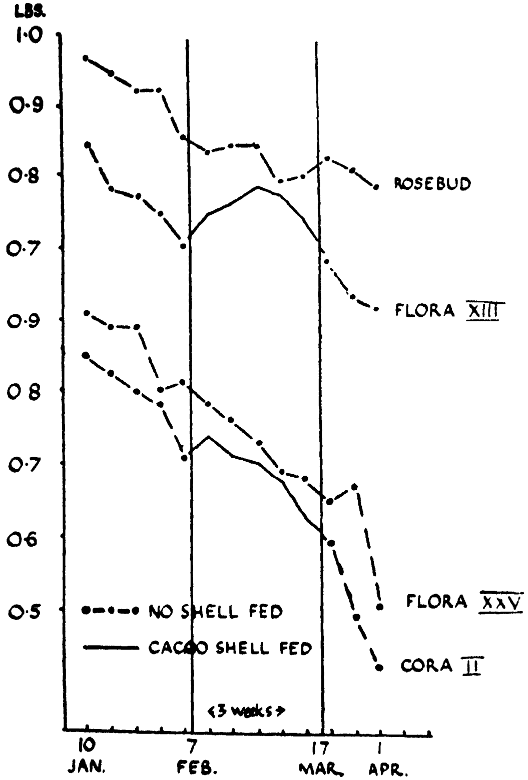

FIG I. The average daily weight of fat for each week.

The average daily weight of fat for each week shown in Fig. 1 shows that during the period in which the experimental cows Flora XIII and Cora II were receiving cacao shell, the fall due to advancing lactation was arrested compared with the periods before shell was given and after it had been discontinued, whereas with the control cows the fall in weight of fat is more uniform.

This result is due to the rise in the percentage of fat during the period of cacao-shell feeding, and very little, if at all, to any increase in the weight of milk. The percentage of solids-not-fat was apparently unaltered.

Fifield Experiment.

We wished to investigate further the rise in fat percentage connected with the feeding of cacao shell, but as no cows were available at the National Institute for Research in Dairying, we accepted the offer of Mr. G. E. Good of Grove Farm, Fifield, near Maidenhead, who kindly placed twenty Friesian cows at our disposal. Trouble had been experienced in the herd with low fat in the morning's milk and some cases of low solids-not-fat.

Due to the limitations of the case the following methods of milk sampling were imposed. As it was not possible to undertake regular analysis of the milks of individual cows, the cows were separated into two groups, one of which was to be used as the experimental group, and the other as a control. In order to make these groups comparable, samples from individual cows were taken at the evening's milking of 23rd March, and the morning's milking of 24th March, and on considering the results of these tests, together with the milk records and stage of lactation, the cows were paired. One of each pair was placed in Group I and the other in Group II.

TABLE IV.

Group 1.				Group II.			
Name of cow.	Breed.	Date of calving.	Calf.	Name of cow.	Breed.	Date of calving.	Calf.
Connie	H.B.F.	Sept/35	2nd	Tulip	F.	Sept/35	4th
Baby	F.	Sept/35	5th	Cissie	F.	Sept/35	6th
Iris	F(ped).	Dec/35	1st	Daisy	H.B.F.	Oct/35	1st
Flora	F.	Dec/35	1st	Darkie	H.B.F.	Nov/35	1st
Beauty	F.	Dec/35	1st	Ruby	H.B.F.	Dec/35	1st
Lulu	H.B.F.	Feb/36	3rd	Diadem	F.	Dec/35	1st
Gipsy	F.	Mar/36	5th	Gladys	F.	Feb/36	2nd

F = Friesian. H.B.F. = Half-bred Friesian.

Seven cows were taken in each group, as it was possible to collect the milk from this number in a 17-gallon churn. The milk of each cow in Group I was weighed, recorded and run over a cooler into the churn. When the milk of all seven cows had been collected it was mixed by plunging at least ten times and a sample taken. The same procedure was adopted with the milk from cows in Group II. These bulk samples were taken at morning and evening milkings on four days of each week.

On four occasions during the experiment, samples of evening milk were taken from each cow separately, tested separately, and the true percentage of fat and solids-not-fat calculated for the bulk. In Table V these results are compared with actual bulk samples

from the churns on those occasions. The close agreement confirms the accuracy of this method of sampling.

TABLE V.

CACAO-SHELL EXPERIMENT AT GROVE FARM, FIFIELD.

Comparison of the results calculated from the analysis of samples from individual cows with bulk samples from a 17-gallon churn.

Date.	Group.	Fat. I.	Fat. II.	Solids-not-fat. I.	Solids-not-fat. II.
1/4/36	Calculated	3·99	3·85	8·34	8·46
31/3/36	Bulk sample	4·05	3·85	8·22	8·44
28/4/36	Calculated	3·80	4·08	8·06	8·25
	Bulk sample	3·80	4·10	8·09	8·20
5/6/36	Calculated	3·87	4·09	8·60	8·73
	Bulk sample	3·88	4·10	8·64	8·72

Feeding.—At the beginning of the experiment all the cows were being fed each day with a maintenance ration of hay, *ad lib.*, 20 lb. mangels or kale, and 3 lb. of a mixture containing equal parts of Silcocks dairy meal and flaked maize, together with a production ration of 2 lb. per gallon over the first gallon, of Silcocks dairy nuts.

After 17th April the quantity of mangels was gradually reduced, and on 1st May, when sufficient grass was available, the cows were put on a summer ration consisting of a maintenance ration of the grass and 3 lb. of maize meal per day (up to 14th May a little hay was fed in the morning).

For a production ration the cows received 2 lb. per gallon Silcocks dairy cake up to 3 gallons per day and 3½ lb. per gallon over the 3 gallons.

Thus, the normal feeding practised on this farm was not altered. It may be worthy of note that the hay in the earlier part of the experiment and the grass in the later stages were not rationed.

The shell was fed in addition to the above feeding, for it was assumed that in the first part of the experiment it would replace a similar quantity of hay, which it resembles in composition (see Table I). It was introduced into the ration gradually, as in the previous experiment. For the first half of the experiment the shell was fed to Group I, and Group II acted as a control. Later, Group II was fed shell, and Group I was taken as a control.

Fig. II shows the average weight of milk and fat, and the percentage of fat per cow per day for each week calculated from all available data.

It will be seen that Group I, with two exceptions, gave less milk

than Group II, also less weight of fat and a lower percentage of fat throughout the experimental period.

Throughout the first half of the experiment, Group I, which was receiving shell, is seen to have given a lower percentage of fat, a lower weight of fat and a smaller increase in milk yield than Group II, though the flush of grass is seen towards the end of the first period to have caused a rise in the milk yield of both groups of cows. During the second half of the experiment, from 12th May when Group II received the shell, the weight of milk and fat, and the percentage of fat, is considerably greater than that yield in Group I control, which in spite of the flush of grass available, exhibits a fall in the weight of fat and percentage of fat when compared with the first period during which the cows received cacao shell.

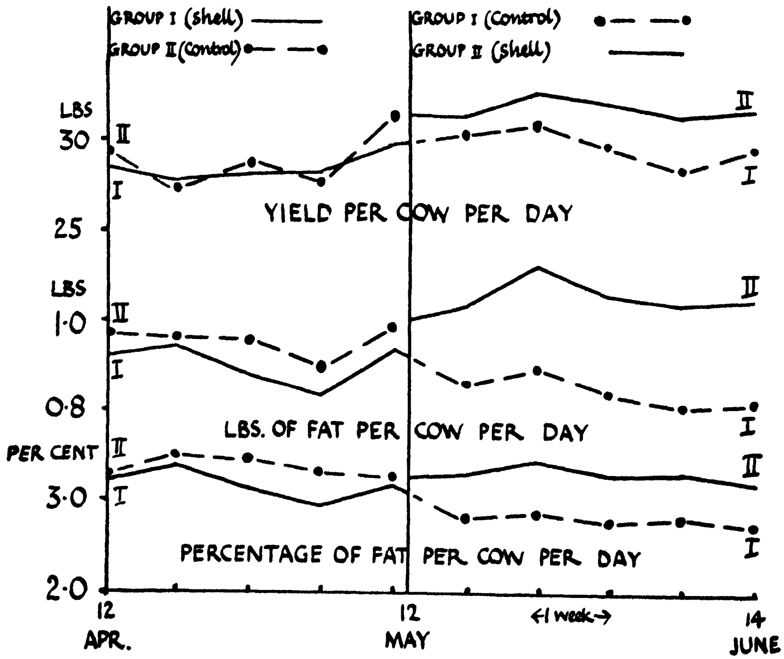

Fig. II. The average weight of milk and fat and the percentage of fat per cow per day in the Fifield experiment.

To find if there was any real rise in the percentage of fat during the feeding of shell, a figure (3·247 per cent.) was obtained representing the true mean fat percentage when either Group I or Group II was receiving the shell, and this was compared with a similar figure (3·068 per cent.) for the periods when no shell was fed.

This shows a difference (0·179 per cent.) in favour of the feeding of shell.

This difference was shown to be statistically significant.*

In this experiment, although some difficulty was experienced in getting a few of the cows to take to the shell at once, no scouring or adverse symptoms were observed.

Other Feeding Results.—Two other farms where cacao shell has been used since October, 1935, were visited. Owing to the difficulty of mixing with the other foods used, the shell was fed to the cows separately. At first they refused to eat it, but very soon got to like it. Ten to fourteen days were taken before the full dose of 2 lb. per day was given to these cows. In time some cows will take unmixed shell with apparent relish.

On the other farm 13 cows were out to grass all the winter, and 12 cows were kept in; all cows had received 2 lb. of cacao shell daily. They all appeared to be in good health.

LITERATURE.

A review of the literature on the subject cannot fall within the scope of this paper, but I cannot conclude without mentioning the experiments carried out by B. H. Gregg[3] at the Harper Adams Agricultural College in 1921. He reports that feeding 2½ lb. cacao shell per day to cows in milk "certainly produced more butter-fat in their milk."

Among the literature on this subject, cases are mentioned from which it appears that *excessive* quantities of shell (1·5 kg. per day given to army horses) are injurious and may cause death. On the other hand, the raising of the percentage of butter-fat in the milk of cows is confirmed by other workers.

Fed at a level of 2 lb. per day to dairy cows no deleterious effects are recorded.

Oskar Hagemann,[4] who conducted an experiment in 1899 in which a cow was fed with a mixture containing cacao shell, reports an increase in the fat percentage of the milk compared with a control cow. He attributes this to an unknown stimulating substance in

* Mean percentage of fat during shell feeding	3·247
" " " " " control periods	3·068
Difference	0·179

$$\frac{\text{Difference}}{\text{Standard error of difference}} = \frac{0\cdot179}{0\cdot0763} = 2\cdot34$$

When the difference is more than twice the value of the standard error of the difference, significance is assumed.

the shell. The 1 per cent. of theobromine which the shell contains would meet this description.

Aplin and Ellenberger feeding 0·4 per cent. theobromine added to the basal grain ration to eight cows for short periods (7 and 6 days), concluded that the mixed milk yield decreased 8 per cent., butter-fat test increased 8 per cent., butter-fat production decreased 1 per cent. Experiments on feeding theobromine to cows are now being conducted at Reading.

Recent work by Folley and White,[5] in which the metabolism of the cow has been put up by other means, has resulted in increased milk secretion, production of milk fat, and of non-fatty solids.

Conclusion.

In conclusion, the value of cacao shell as a foodstuff for cattle is not only enhanced, as shown by Kon and Henry, by the vitamin D which it contains, but an increase of the weight and percentage of butter-fat is indicated by feeding 2 lb. daily of cacao shell to cows in milk.

Our thanks are due to Mr. A. W. Knapp and Messrs. Cadbury Brothers, Ltd., Bournville, whose collaboration and support has made this investigation possible. We are indebted to Mr. G. E. Good for the use of the cows at Fifield, and to Mr. A Wagstaff and Miss J. Lambourn who conducted the analyses.

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ICE-CREAM*

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Although ices and iced drinks were known and favoured by the ancient Greeks and Romans, it is less than 300 years since their use extended to this country. Generally speaking, any knowledge of their their manufacture was for long confined to that of chefs—French and Italian—and in consequence, such products were enjoyed only by the rich.

Except that milk, and cream in small quantities, began to be introduced into the mixtures to be frozen, there was little further development until comparatively recent times. The mix (mixture) was nothing more than a recipe, each maker varying his ingredients according to whim or fancy. The middle of last century marked the first advance in the process of evolution that was to follow, and for the first time ice-cream was manufactured on a factory scale in America. It was not, however, until the introduction of ice-making machinery that real progress was made. From then onwards American production increased, slowly to begin with and quickly later, until the peak point was reached in 1930. During that year the consumption amounted to 3 gallons per head of the population.

Ice-cream manufacture in this country, despite recent advances that have been made, still lags sadly behind. Unfortunately, the "powers that be," unlike those in America, have given no official encouragement to the production of the higher grade product, with the result that makers of such are constantly exposed to the cut-throat competition set up by the cheaper article.

It must be admitted that the choice of standards of quality is bound to be somewhat arbitrary. Even in America there is a strange lack of unanimity in this respect, each State possessing its own standards for butter-fat and total milk solids. In the case of butter-fat the variation is from 8 to 14 per cent.; total milk solids on the other hand, though not always specified, are, in most cases, fixed at from 18 to 20 per cent. Where total solids, i.e. all solids including sugar, etc., are stated instead of total milk solids, the

* Paper read at the July meeting, Glasgow, 1936.

variation is from 30 to 35 per cent. Experience in this country would seem to favour standards of 10 and 20 per cent. respectively for butter-fat and total milk solids, figures with which I personally agree. It would, I think, also be desirable to add, as has been done in certain countries, a standard of hygienic quality based on bacterial count (100,000–150,000 organisms per gram).

It might be argued that there would still be a place for the lower quality product at present on the market, just as there would be for water ices and the like. Even conceding this, it is difficult to imagine why such a product, usually containing a fat content less than that of milk, should be allowed to masquerade as a form of cream. My suggestion, therefore, would be that the expression "ice-cream" be confined to the description of the higher grade product and that "milk ice" or "plain ice" be the designation descriptive of the lower grade product. To use the terms *cream-ice* and *ice-cream*, an arrangement which has been suggested, would in my opinion lead nowhere, as both mean practically the same thing to the public.

In the short time at my disposal I can only briefly describe the process of manufacture. It will be understood that there are many other considerations of importance, as for instance the choice and quality of the raw materials to be used, variations in technique, and the details of equipment necessary. Naturally, there is a vast difference between commercial practice and manufacture for domestic use; yet, whatever the difference, the essential principles are the same—a mix must first be prepared or, if not, purchased; a freezing medium of some sort is essential, and certain equipment is necessary for freezing and storing purposes. A low temperature must be attained during freezing and for this the domestic maker may have to be content with a modified type of freezer and the use of freezing salts. The common type of tub freezer with its mixture of ice and salt has the advantage of greater output, and is definitely more economical. For manufacture on a larger scale, batch-freezing by brine or direct expansion is more practicable, more especially if the freezer is of the horizontal type. The most recent advance has been the introduction of the continuous freezer in which the mix and air are propelled in regulated proportions through the freezer chamber. In this type, which is suitable only for very large outputs, the mix is in the freezer for a matter of 10–15 seconds. In the case of the smaller types of freezer the freezing period varies from 10–20 minutes.

The composition and preparation of the mix should probably claim our main attention, as most points of consideration are common

to all mixes, whether for large- or small-scale manufacture. Assuming a mix containing 10 per cent. of butter-fat, the other contents might be arranged as follows:—Solids not fat, 12 per cent.; sugar, 13 per cent.; gelatine, ½ per cent.

The milk contents would be provided in the form of combinations of cream, milk, butter, evaporated milk, sweetened condensed milk, separated milk and skim-milk powder according to availability of supplies and consideration of cost. There would, as a rule, be a preference to use cream as the main source of fat, if the price were no serious handicap.

The sugar would in all probability be provided in granulated form, either to meet the total needs of the mix or to supplement the sugar content of sweetened condensed milk should this be added. Recent experimental work would seem to indicate that glucose might be usefully included as a partial substitute, probably to the extent of one-third, keeping in mind the fact that it is only about 80 per cent. as sweet as cane or beet sugar.

Most manufacturers use gelatine which, in addition to its powerful stabilizing influence, has some considerable value in rendering the product more digestible. Gums, e.g. gum tragacanth, are now rarely used unless in combination with gelatin, and starches, still the main constituent in our custard mixes, are not to be recommended in the making of the better type of ice-cream.

Various so-called ice-cream improvers, some enzymic in action, have been suggested, but except for the poorer types of mix, the use of these is neither necessary nor desirable.

One might elaborate the particular effects of the different constituents on the various physical properties of the mix, as for instance on the whipping property and freezing point and on the resulting body and texture. It will be enough to say that the manufacturer's main concern is to secure an ice-cream of satisfactory over-run, attractive in flavour and smooth of texture, and capable of standing up to a certain amount of temperature fluctuation. Over-sweetness is to be avoided, as also is the inclusion of too much solids-not-fat. The latter, because of the extra lactose introduced, may result in the formation of lactose crystals and cause the common fault known as "sandiness."

In compiling the mix it will in most cases be found convenient to express the weight of the various ingredients in terms of 100 lb. Smaller or larger amounts can then be easily ascertained. On this basis the following mixes are advanced as conforming with the percentage composition already stated.

1. A mix comprising 50 per cent. cream, separated milk, skim-milk powder, sugar and gelatine.

	Lb.
Cream	20
Separated milk	60·62
Skim-milk powder	5·88
Sugar	13·00
Gelatine	·50

2. A mix comprising 50 per cent. cream, separated milk, evaporated milk, sugar and gelatine.

	Lb.
Cream	13·33
Separated milk	36·13
Evaporated milk	37·04
Sugar	13·00
Gelatine	·50

Tables can be prepared to provide quite a multiplicity of mixes of different compositions and thus eliminate a certain amount of tedious calculation.

The ingredients decided upon, it now remains to bring them together in their proper sequence prior to pasteurisation, i.e. to the heating of the mix to 145°–150° F. for 30 minutes. Care, however, must be taken to avoid lumpiness, especially of skim-milk powder, if this be included, and there is a good deal of evidence in favour of soaking the gelatine in cold water for half an hour before adding it to the hot mix. The next step in the process is that known as homogenization which, in effect, means the treatment of the hot mix by pressure at the rate of 2,000–3,000 lb. per square inch. By breaking up the fat clumps and causing a finer dispersion of the fat a mix of improved whipping ability and a product of better body and texture are obtained. Of course, it will be understood that the use of homogenizers is more or less confined to large-scale practice.

Then follows the rapid cooling of the mix to 40° F., or preferably lower, and finally the 12–24-hour period of ageing, both of which, as in the case of so many of the other treatments, exercise a beneficial effect on the body and texture of the final product. The mix is then ready to freeze and the flavour chosen added, either before freezing commences or immediately after. Generally about half the specified quantity of flavour suffices, except perhaps in the case of fruit extracts.

It should be borne in mind that the objects to be attained during freezing are:—

1. To reduce the temperature of the mix to the point of solidification, i.e. to 26–28° F.—this varies according to the

composition of the mix—and then to lower the temperature still further to a point suitable for discharge, viz. from 20–24° F.

2. To introduce into the mix and fix within it as part of its structure a certain proportion of finely dispersed air. Besides adding to the over-run or swell of the ice-cream by from 60–90 per cent. of the original volume of the mix, this air has an important bearing on the body, texture and palatability of the product.

When the ice-cream is to be served immediately it will generally be found advisable to freeze to a rather firmer consistency than usual. If to be filled into cartons, or otherwise conserved, discharge should be made when the ice-cream assumes a dull appearance and is just stiff enough to pile in the container into which it is to be placed.

Subsequent temperature control is important and depends on when and how the product is to be served or disposed of. When using an ice-salt freezing mixture it is usually advisable to increase the ice proportion in order to prevent over-hardening. In large-scale operations on the other hand, the frozen product may be transferred to store and kept at zero to −5° F. or even lower until disposal is in view. Constancy of temperature is vital during this period. It is in the final stages, viz. when the ice-cream is made available to the public that solidified carbon dioxide finds its usefulness—but that is another story.

THE INSECTS ASSOCIATED WITH BRACKEN*

By Agnes A. Meikle

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In the West of Scotland, observations on the insects associated with bracken have been carried out at Garelochhead, Milngavie and Castle Semple during the last few years. Most of the work was done by the late J. I. Armour, B.Sc.,† in the years 1932 and 1933 at Garelochhead and Milngavie.

The insects found feeding on bracken are:—Moth caterpillars, feeding on the roots (1 sp.), feeding on the leaves (3 spp.); wire-worms (2 spp.) mining the underground part of the stem; a Cercopid bug sucking the sap; saw-fly larvæ (several spp.) eating the leaves; the maggots of several flies, viz. stem-miners (2 spp.), leaf-miner (1 sp.), leaf-roller (1 sp.), an undetermined gall-former and several gall-gnats.

On the undersurface of the bracken stems, at the base of each branch, there is a small pad of tissue known as the nectary. While the part of the plant above them is not yet unrolled, these pads are covered with fluid, and they attract many insects. Those observed are:—Bees (2 spp.), ants (several spp.), Elaterid beetles and numerous diptera.

Armour left detailed notes on the habits and life-history of the root-feeding caterpillar of the northern swift moth (*Hepialus velleda*, Hb.) and of two Diptera, one (*Chirosia albitarsis*, Zett.) with a stem-mining maggot, and the other (*Pycnoglossa flavipennis*, Fln.) with a leaf-mining maggot. A short summary of the habits and life-history of the three insects is given as follows.

Hepialus velleda, Hb. (the Northern Swift moth).—The adults appear at the beginning of June and remain on the wing until the end of the month. Emergence takes place early in the evening and the newly-emerged moths climb up the stems of the bracken. When the wings are fully extended, the males begin their evening flight, which is often remarkable for beginning at exactly the same time each night and terminating abruptly thirty minutes later. This phenomenon is, however, not constant. While the newly-emerged males are on the wing, the older males and egg-laying females are

* Paper read at the July meeting, Glasgow, 1936.

† James Inglis Armour, as a candidate for the degree of B.Sc.(Agric.) with Honours in the group of Agricultural Zoology, undertook a survey of the insects associated with bracken. His observations were considered worthy of publication but this was prevented by an illness which ended fatally within a few months of his graduation. The records of his work have been checked and this summary is offered for its value in connection with the general problems of the bracken pest.

flying about the bracken clumps. The newly-emerged females remain on the stems and start vibrating their wings. The males in the vicinity hurry to them, fighting for possession. When the first male touches the female her wings cease to vibrate. This vibration does not seem to be the principal feature of sex attraction because even females with undeveloped, crumpled wings attract males.

The moths remain paired for about four and a half hours. After this time the female swings the male clear and after a few minutes' rest she starts her first egg-laying flight. The eggs are not all laid during this flight. The female flies again in the evening and the following morning until all the eggs are laid. The total number may be as many as 1,218 and take four or five days to lay. The eggs are laid while the female is hovering over the bracken, the wings being vibrated during egg-laying. The eggs are round, 0·5 mm. in diameter, white at first, but turning blue-black. When kept on damp blotting-paper they hatch in 23–26 days.

The larval stage lasts normally 21–22 months and is spent entirely underground. By examination of the underground parts of the bracken and the surrounding vegetation where the caterpillars are plentiful it is seen that the principal food of the older larvæ is the adventitious roots of the bracken and that of the younger larvæ, the roots of grass. Armour, in studying the underground habits of the caterpillar, used a *sulterrarium* (cf. Main[1]). In this he placed a caterpillar and watched its tunnelling activities. The tunnels have a diameter two or three times that of the larva and are lined throughout with silk. The larva can turn itself but its usual method of retreat is by going backwards. This it can do with greater rapidity than going forwards. When the caterpillar is fully fed, at about the end of April, it constructs a vertical tunnel to the surface which it lines with silk to within the top two inches. This completed, the larva retires to the horizontal tunnel where it pupates. The pupa is characterized by motility but, contrary to common belief, it is not able to force its way through hard compact soil.

The caterpillars were often found to be parasitized by an entomophagous fungus *Cordyceps gracilis*, less frequently by insect parasites, the Ichneumons *Alomya debellator*, F. and *A. debellator*, F. var. *nigra*, Grav., and the Braconid *Meteorus micropterus*, Hal.

Chirosia albitarsis, Zett.—The larvæ of this fly mine in the basal part of the bracken stem, where more than one maggot may be found. The fly emerges at the end of May and starts egg-laying almost immediately on the young bracken shoots, when these are only about eight inches high. The eggs are laid on the flat surface of the shoot, as many as 42 being found on one stem. The newly-hatched larvæ creep down the stem and burrow into the tissue just

above ground-level, tunnelling being confined to the basal part of the stem. After a feeding period of three weeks, pupation takes place either in the tunnels, just below the cuticle of the stem, or in the soil. The pupæ formed before the middle of June produce flies in twenty days, but if pupation does not take place until later no flies emerge before the following season.

Two different Hymenopteron parasites emerged from puparia of this fly, the Pteromalid *Halticoptera patellana*, Dalm. and the Ichneumonid *Phygadeuon rotundipennis*, Thoms.

Pycnoglossa flavipennis, Fln.—So far this fly has not been traced in the literature dealing with the insects of bracken. The larva mines in the tip of the bracken pinnule. The adults are on the wing early in June and a second generation in August. The eggs are laid singly on the undersurface of the pinnule near the mid-rib. The newly-hatched larva enters the tissue and burrows towards the tip of the pinnule. At first mining is confined to one side of the mid-rib until the tip is reached, then the larva works down the other side to the level of the starting point. After this both sides are excavated evenly. The full-fed larva leaves the mine and pupates in the soil.

This larva was found to be heavily parasitized by the Braconid *Adelura apii*, Curt. and the Pteromalid *Lamprotatus gibbus*, Walk.

The attack of two other flies was also observed, viz. *Chirosia crassiseta*, Stein, with a stem-mining larva and *Chirosia parvicornis*, Zett., with a leaf-rolling larva. These have been already described by Cameron.[2] He states that in the case of the latter there is evidence of a reduced second generation, but according to Armour's observations there are two generations in the year. He bases this statement on the fact that he found in August and September as well as in June many inrolled leaves containing larvæ.

No evidence has been noted of serious injury to bracken caused by any of these insects, such as might be applied for its control, but in the case of *Hepialus* it has been noticed that the caterpillars are most abundant in areas where the plants show fungus disease, and their presence seems to hasten the death of the plant.

Thanks are extended to the Director of the Imperial Institute of Entomology for the naming of specimens of *Chirosia albitarsis*, Zett., *Pycnoglossa flavipennis*, Fln., and the parsitic Hymenoptera.

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CHICKEN REARING FOR EGG PRODUCTION*

By Miss A. Kinross

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Chicken rearing has now become rather a complicated and worrying job due chiefly to the problem of disease. Poultry farmers who wish to be successful and to avoid troubles should hatch and rear from their own breeding stock, avoiding buying in eggs and day-olds or even three-month-old pullets, even although these may be bought from apparently healthy farms. I believe that immunity from all present diseases will only be brought about by doing so, even if trouble has been present. Select the breeders first and always for health, constitution or vigour. Do not worry about trap nest records but go out for all outward signs indicative of health.

If disease exists on the farm, difficulty may be experienced in selecting a sufficient number of good birds, but do not let that worry you: be content to rear a smaller stock rather than include poor birds in the breeding pen.

One of the most difficult points to select for at present is eye colour. Maybe some of us stress it too much, but why within recent years should the eye lose to such an abnormal extent its natural pigment? We all know that it exists in growing chickens up to a point and in many cases it gradually disappears. I consider it a serious sign of lack of health. Often in paralysis there is no loss of eye colour, but what of the eye that becomes grey: and often during the first laying season, birds may go totally blind. I am inclined to think that birds with poor eye colour should be regarded with suspicion.

I consider that from January onwards is quite soon enough for hatching for all practical purposes and avoid the craze for starting in November and December. Doubtless to get all the pullets one requires within a shorter period may mean keeping a few extra breeders and increasing the rearing appliances slightly, but there will be more uniformity in age of the future stock. From January to the middle of April are the best months to have all stock hatched for egg production.

Regarding the method of incubation I do not think that the use of mammoth or small machines has much influence on the health of the chickens. We all know that there has been considerable controversy on large versus small machines and that the former have been blamed as one of the causes of disease of late years. Doubtless

* Summary of a paper read at the July meeting, Glasgow, 1936.

very fine day-olds are hatched but whether they have any effect on future health I am not prepared to argue.

I advocate outdoor rearing for future egg producers, getting the chicks outside as soon as practicable. Personally, I consider the method adopted during the first week does not matter, that is, if you like, use the battery brooder. Brooder house compartments, however heated, or straight into a small house with hover or into an outdoor brooder. Any method except the latter provides control during the first week. There is greater risk from chill by using the outdoor brooder right away. The only drawback to the indoor methods to start them is moving of chickens at 7–10 days. Even after they are put into outdoor brooders, much depends on the weather how soon they can be let into the run, but do so at the first opportunity. Those who have had no experience of this method will not like it, as it certainly causes more labour and care, but later one is rewarded. If care is exercised there need be no increase in mortality in the early weeks of rearing.

Many poultry farmers to-day withdraw the heat too soon, believing, as they say, in hardening the chicken. This is often a serious mistake. I believe in heat as long as necessary, and here again the weather has to be considered. Any time after we take away the heat it has to be given again if the weather suddenly becomes cold. I believe there would be less chicken coccidiosis at about six weeks if they still had heat. Its removal too soon leading to huddling for warmth which is very bad. We have a plan which works very well in outdoor rearers. After six weeks we remove the hover, put in a slat at one end with straw on top, a gale lamp is placed in the centre of the slat and we hang a curtain made of a piece of flannelette or hessian to shut off about a third or so of the rearer. This gives protection and the chicks are contented and happy. The curtain and lamp are removed as soon as possible and the chickens remain in the rearer until they are at least eight weeks old. The cockerels are taken out at the time the pullets go into arks or larger houses.

I have come to the conclusion that I do not like arks for pullets. I much prefer small houses, so that they can begin to perch. In every way perching is preferable to slats:—(1) The pullets get greater benefit from fresh air and ventilation. (2) No more birds can be crowded into the houses than the perching room allows, and there is much less risk of overcrowding. (3) Colds are avoided. (4) A chicken much prefers to perch than sit on slats; and, lastly, I am certain that if poultry appliance makers were first and foremost poultry farmers, they would avoid slats like poison; but they have the appliances to sell and if they can assure the buyer that an appliance will take double the number of birds and make it appear

a bargain, that is their business. Of all articles to clean, slats are the worst. The chickens are breathing in smell from droppings all night and every night. I am certain on most farms the boards underneath the slats are allowed to accumulate droppings for a week and oftentimes much longer. I call such a condition a system of slow poisoning of birds. When you visit us, you may ask why we have arks. Well, they are there and for want of funds one cannot scrap appliances all at once. I do not care for fold units, either, for rearing growing pullets.

Rightly or wrongly I advocate a return to wet mash and grain feeding. I am not giving particulars of a mash, for we all have different ideas on what should be the best one. I really do not think that is very important as long as the mash is suitable for any particular farm. I think it should vary to suit soil and kind of grass in particular. There is more goodness in soil and grass of new pasture than is found in one which has been laid down for a great many years. Where practicable I should like to see a fourth or a third of any poultry farm ploughed and seeded every year. This would provide fresh soil and succulent grass and would prevent the tufty rank conditions which do eventually come.

My reasons for recommending wet mash and grain feeding are:—(1) There is tremendous saving in the food bill; the mash hopper has yet to be invented which entirely prevents waste. (2) To save labour one constantly finds hoppers filled too full. (3) Mash is added from time to time so that they are rarely empty. What about stale musty mash? (4) Dry feeding keeps the birds too much inside lying around hoppers, therefore, on free range they are not taking full advantage of being outside. (5) In most districts, the weather rarely permits of hoppers being placed outside and even so, the ground around is absolutely polluted. If there is a shortage of hoppers, feather picking, etc., is induced.

There is one other point in connection with feeding or rather the composition of the mash for growing pullets. I do think we make the mistake of reducing the mash, that is, feeding a poorer one to pullets, say from eight weeks onwards. Long ago we used only one mash, until they were put on to the laying one without waiting until the pullet was fully matured. We have all more or less blindly followed somebody's idea of keeping back pullets. That is altogether wrong. If they receive a check or fail to keep growing, then it is very difficult to start them off again. Now that trouble is just round the corner, opportunity is given for one or other to get a hold. Instead of reducing the mash it should be enriched to practically the same composition of a good laying one. I believe this is even more important on rough old pasture.

THE MEMBERSHIP OF THE ASSOCIATION

A chance remark by a member at the last General Meeting of the Association raised the question of the proportion of members in different branches of the agricultural profession.

The question is not easy to answer, as some members could rightly claim a place in more than one category. Thus eight or nine members belong to both Government departments and the staff of a university, while a few members of commercial organizations are known to be engaged entirely in research. Again, those placed in the category of private members may be retired members of the profession or members in active work, but about whom no information is available. Further, the relationship of a research institute to a university is not always easily defined and there arises in consequence some vagueness as to the status of certain members.

But admitting that difficulties of this kind can, and do, arise, it is thought that the following table gives a fair representation of the composition of the Association.

	Employing body.		Number of members.	Percentage.
1.	Government departments		32	6·5
2.	Public authorities, such as marketing boards, etc.		10	2·0
3.	Universities, colleges and schools—			
	(*a*) Universities	128		
	(*b*) Colleges	65		
	(*c*) Schools	3		
			196	39·8
4.	Research institutes, not directly connected with universities		21	4·3
5.	County authorities		150	30·5
6.	Commercial firms or organizations at home		31	6·3
7.	Public authorities abroad		17	3·5
8.	Commercial firms abroad..		2	0·4
9.	Unattached or private members		33	6·7
	Total		492	100·0

It is hoped that the classification may not be without interest to members and may do something to dispel erroneous impressions founded only on the attendance of conferences.

RECENT ACTIVITIES

THE 1936 SUMMER MEETING, GLASGOW

Those who arrived in Glasgow on the Monday were invited to meet the staff of the West of Scotland College of Agriculture, and each other, at an informal reception in the College that evening, and about two dozen availed themselves of this. To the tiring railway journey they had to add the seemingly endless stairs and passages that led to the Students' Union in the basement, and no doubt the light refreshments that awaited them there were necessary as well as welcome.

The Conference proper commenced on Tuesday with committees, and the first Paper Reading Session. On Tuesday evening, the Inaugural Dinner took place in the "Rhul" Restaurant and was attended by fifty-one members and guests. Professor J. A. Hanley presided at the dinner and in his speech of welcome he introduced the guests who were Lord Rowallan, Bailie John M. Biggar, Mr. John Speir of Newton, and Mr. William Young of Dalmoak. Lord Rowallan replied briefly on behalf of the guests, and after votes of thanks had been proposed by Mr. J. Hunter Smith, the remainder of the evening was given over to conversation. Two members present that evening, Mr. E. Druce and Capt. J. Golding, had been present at the Glasgow meeting of 1906, exactly 30 years previously. Perhaps one might make mention of the solicitude of certain members for the dairy industry in presenting a distinguished professor with a glass of milk, a gift received and quaffed with grace.

Wednesday afternoon was occupied with the first of the excursions, and about fifty members travelled by bus and car either west to Dalmoak, or east to the fruit gardens of Lanarkshire. The horticultural visit drew the smaller attendance, as was only natural, but the run through rural Clydeside was enjoyed by those participating, although taken at a relatively uninteresting season of the year; a similar journey in springtime would furnish a memorable spectacle of fruit blossom filling at times the whole valley from the river's brim to the tops of the slopes like a cloud of fragrant mist. Stops were made at the premises of Messrs. James Warnock and Messrs. Bannantyne and Jackson, and the party was very kindly supplied with tea at the latter establishment.

The route taken by the agricultural section also led along the Clyde, but a very different vista met the eye. This was the

industrial, the navigable Clyde, and great interest was taken in the stocks which had cradled the *Queen Mary* at Clydebank. The river route was followed until the county town of Dumbarton was reached and then the bus turned north and followed the Loch Lomond road for a mile or so to arrive at Dalmoak Castle and farm. Here we were met by our host, Mr. Young, who conducted us first over his steading and demonstrated on his Clydesdales and Ayrshires: a notable family of the latter breed involving five generations being paraded and provoking much favourable comment in addition to causing much activity amongst our cameramen. Thereafter, the party was taken over the fields before being entertained to a royal tea in the dining-room of the mansion and, following on this, those who were able climbed to the top of the tower and were rewarded with a panoramic view of an interesting countryside. A very pleasant visit was fitly concluded by the taking of a group-photograph on the steps of the porch. A detour was made on the return journey to give the party a glimpse of Loch Lomond.

Thursday's excursion was again excellently attended, as over fifty made the journey to Auchincruive. The road this time led southward through the eastern portion of Renfrewshire and, after reaching a considerable elevation in the region of Fenwick Moor (where there was peat in plenty to interest certain of the company), ran down into the fertile Ayrshire plain through Kilmarnock and on to the coast. A short run across country and Auchincruive was reached, the first call being made at the Hannah Dairy Research Institute. Here Dr. Wright and Mr. Fowler were waiting, and after a brief explanatory talk the party proceeded to inspect the two grass-drying installations at work, the process being followed with interest from the moment when the wet material was loaded on the driers until it appeared bagged from the mill. Unfortunately, rain was falling from grey skies at this time and many would willingly have submitted their garments to the kindly offices of the drying plant—short of the final process—but time was short and the buses were re-entered to reach the College Estate a few minutes later.

After a welcome from the chairman of the College Governors, Mr. J. Harling Turner, C.B.E., the company was addressed by Dr. McCandlish on the problem of bloat in farm animals, and then Principal Paterson took charge and demonstrated on the "Sprout" cabinets used in the interesting feeding experiments which he had discussed in the Paper Reading Session. A visit to the very up-to-date piggery followed and the excellent herd of Large Whites was much admired, the feeding and management of the animals being

explained by the Principal. Lack of time prevented every department being visited by the whole party, and so at this point sections were formed under leaders according to predominating interests, and after a quick look round these joined forces again to attack the tea provided in the mansion-house. The return journey to Glasgow was performed as speedily as possible in view of the General Meeting to be held the same evening.

The Clyde Estuary is a unique and prized possession of Glasgow and the West, and no true picture of the College's sphere of influence could be considered complete without it. The full-day excursion was therefore planned to bring the members into the counties of Argyll and Bute, whose genius is so different from that of the other counties visited, and when it is realized that 60 per cent. of those attending the meeting remained for that "difficult" last day, the venture would appear to have been justified.

Thus it was that the boat-train on the Friday morning ran down the left bank of the Clyde through the whole length of Renfrewshire carrying some thirty-three of our number. The rail journey itself was not without some interest, for at one point the train passed slowly within a stone's throw of the ruined *l'Atlantique*, and later, as it climbed the hill above Greenock, a view of the peaks and fjords of Argyll was obtained—or would have been had the day not already begun to give evidence of her inconstancy. Once on board the steamer the fine rain was almost an asset, for it provided an authentic nautical touch, and those who witnessed the beauty of the Toward Lighthouse circled in a rainbow must have forgiven much. The spirit of optimism was indeed widespread throughout the company, and one member was heard to remark that the mist effects on the hills brought out their contours with a perfection that could not have been obtained with a clear air, and this was vastly comforting to those with local knowledge who were inclined to bemoan other missed effects.

Each port of call on the voyage was subjected to an interested scrutiny and the Scots present were considerably astonished at the success which rewarded the Southerners' efforts to pronounce, for example, Tighnabruaich. Reflection, however, showed that those most proficient were of Cymric origin and the wonder was dispelled.

After lunch the company reassembled on deck to find that the steamer was coasting the shores of Arran and ere long Brodick Bay was reached. The sun was by this time shining brightly, but only the foothills of the Arran range were visible, and so it remained for the rest of the day, the white garment that concealed the beauties of the peaks never being withdrawn. An opportunity to view the

landscape at close quarters was afforded by the kindness of Mr. Donald MacKelvie in providing buses to convey us from Brodick to Lamlash and so bring us to the object of our excursion—a visit to his famous potato station. It was a great pleasure to meet such a charming personality as Mr. MacKelvie, and to have so thorough a demonstration from him of the different varieties which are at present engaging his attention, and it was an added joy to inspect the splendid ponies which he paraded for us.

All too soon we had to make our way to the pier and embark for the return. Traffic was exceptionally busy owing to the departure of holiday-makers from the island with the end of the month, and as a result the arrival in Glasgow was an hour behind scheduled time, but the excellent morale with which the day had been begun was maintained even yet, and members departed for their various destinations still in the best of spirits. Those who remained behind were left with pleasant memories of the Association's visit, and a sincere hope that in the not too distant future the west of Scotland may be favoured with another.

S. MURRAY BODEN.

THE BRITISH ASSOCIATION MEETING, BLACKPOOL, 1936

Since the meeting at Leicester in 1932, more and more attention has been given by the British Association to the sociological effects of scientific progress, until at Blackpool last September almost every section staged a discussion on this aspect of its particular science, and the President of the Association, Sir Josiah Stamp, took as the subject of his presidential address "The Impact of Science on Society." It is not only that the very fabric of our civilization seems to be threatened by the prostitution of chemical and physical discovery to the destruction of human life through poison gases and bombing from the air, but that every new scientific discovery, process or invention may affect our ordinary everyday life in some way or other. Especially is this true of rural life, and it was therefore fitting that the Agricultural Section should devote its first session to a discussion on the reaction of British farming to the new knowledge on human nutrition.

NATIONAL NUTRITION AND BRITISH AGRICULTURE.

The subject was introduced by Sir John Orr who showed that our national diet was so deficient in accessories such as vitamins and minerals and, for children and pregnant or nursing mothers, in

proteins, as to impair the physique and disease-resistance of our people. Almost double the present consumption of milk, eggs, fruit and vegetables was desirable, and this, at present prices, working people could not afford. Our agricultural policy should be based on the food requirements of our people. Could this be done? Sir Daniel Hall replied in the affirmative, for, since two-fifths of our food was imported, we could choose what we imported and what we produced. He held that the existing subsidies on wheat and sugar were ill-designed. Both were concentrated foods and therefore far cheaper to import, per food unit, than the bulkier foods which our national diet was deficient in, and which could be produced in far larger quantities, and at a lower cost to the consumer, if the encouragement now given to growing wheat and sugar beet were diverted to their production, and if the methods of distribution were reformed. Could British farming respond to such a policy? Prof. J. A. S. Watson replied that it could, and without seriously diminishing the number of beef-cattle and sheep, provided our grass-lands were subjected to a more intensive system of management, or grassland farming replaced by a system of alternate husbandry, and provided more double purpose crops were grown, and more concentrated feeding stuffs were imported. But to provide cheaper milk, the average life of healthy cows must, and could be, more than doubled by the elimination of bovine disease. Professor H. D. Kay confirmed this last statement and added that the average yield of milk per cow must and could be greatly increased, for the average of milk-recorded herds was 55 per cent. higher than the general average. With regard to imported food-stuffs, he thought a large proportion could be replaced by artificially dried grass.

Farm and Factory.

In passing through farms in the Fylde of Lancashire, east of Blackpool, it was noticed that in some respects the policy outlined above had already been put into practice. Little arable land was to be seen; it was essentially an area of grass farms for dairy cattle, pigs and poultry. Large movable poultry houses were a feature of the landscape. In this, as in other respects, the influence of the Farm Institute at Hutton was apparent. The afternoon spent at the Institute was most enlightening, especially in respect of the up-to-date methods of management of all three classes of stock. The milking, recording, and feeding according to the milk yield of each cow, appeared to be the acme of efficiency, economy and hygiene. It was interesting to learn that, at long last, accommodation for the agricultural school is to be provided on the farm.

Another aspect of the influence of scientific invention on country life was revealed during the Saturday's excursion to the Lake District. The party stopped on the way at Milnthorpe, where Messrs. Libby have estabished a factory for evaporating milk. From an area round the factory having a radius of 50 miles, 600 farmers send their milk daily. On arrival the milk is automatically weighed, and samples taken for fat content (but not paid for on that basis). It is then strained and pasteurized, evaporated under low pressure to remove two-thirds of the water, the resulting syrupy liquid cooled and automatically canned, and the filled cans automatically soldered, sterilized, labelled and packed. From the rapidity with which the process was carried out, the full capacity of the factory should be, and was stated to be, 100,000 ½-lb. or 1-lb. cans of evaporated milk a day. What must the influence of this means of disposing of milk be on rural life? A reasonable price is paid to the milk producers, and it seems almost certain that dairying as a farm industry in the area covered must eventually cease to exist.

ECONOMIC PROBLEMS OF MILK PRODUCTION.

The discussion on this subject was opened by Mr. C. Law, who described his farm in the Calder Valley of East Lancashire and showed how, by improving his pastures and his stock and by using up-to-date methods of management, he had been able to secure a profit of nearly 2d a gallon on milk sold for liquid consumption. Mr. J. L. Davies followed with a comprehensive account of the work of the Milk Marketing Board. During the past year 70 per cent. of the milk marketed was sold for liquid consumption and 30 per cent. to factories, the returns in money being 87 and 13 per cent. respectively. The factory milk was converted into (1) butter, (2) cheese, and (3) other products, in about equal proportions. These manufactured products formed only 11 per cent. of the total consumption or, taking butter and cheese alone, 10 per cent., 90 per cent. being imported. However, the policy of the Board was to increase the consumption of liquid milk, which seemed to be chiefly limited by the purchasing power of the consumers. For, while the consumption of liquid milk averaged 0·4 of a pint per head per day for the whole country, it was only 0·25 of a pint or less in the depressed areas. To meet this difficulty, a twelve months' experiment was being made in the Rhondda Valley where milk was now being provided at 2d. a pint for pregnant and nursing mothers and children under school age, and further encouragement was being given to the consumption of milk in elementary schools. Publicity, based on a nutritional appeal, had been carried out, and during the

past twelve months the number of milk bars in the country had increased from 2 to 500.

Mr. John Orr pointed out that farmers must not look for any increase in the price of milk, and must concentrate their attention on decreasing cost of production. There were huge areas of grass-land in this country which could be so improved by proper management as to save 2d. a gallon on the milk produced. The starch-equivalent of the grass of well-managed grass-land cost only a quarter of that of purchased cake and meal. He exhibited a number of turves showing the astounding improvement produced by good management, this involving ploughing up and resowing in the case of some of the grass-lands in Lancashire. Mr. A. D. Buchanan Smith dealt with breeding for milk. He would breed from bulls whose progeny are more or less uniform as milk producers. But it was a mistake to try to get all the good qualities desired in one bull. This should rather be done by subsequent matings. The dual purpose type had this to be said for it that by suitable crossing adjustments of a herd to changing market requirements could be quickly made.

In the course of a long discussion that followed the reading of the papers, Mr. J. M. Caie referred to the greater number of attested herds in Scotland than in England. Mr. Davies replied that a great increase of such herds was now taking place in England and that it was hoped to bring T.T. milk into the Milk Marketing Scheme.

SOIL SCIENCE.

Professor Hendrick's presidential address on "Soil Science in the Twentieth Century" was a masterly résumé of recent progress. Starting with our limited knowledge at the end of the last century, based on chemical and mechanical analyses of soils, together with manurial experiments in Britain, he showed how our views had been influenced by new knowledge of (1) arid and alkaline soils in other parts of the Empire and U.S.A., (2) soil genetics as taught by the Russian school of pedologists, (3) soil colloids in relation to base exchange and to acidity and alkalinity, on which his own work with drain gauges at Craibstone had a bearing. The address should be in the hands of every agricultural student who is unable to study for himself advanced textbooks on the subject.

A discussion on soil problems followed. Professor G. W. Robinson dealt with the difficulty of classifying soil profiles, having regard to human interference and the factors that determined their development. These factors he put in the following order, (1) "moisture régime," (2) temperature, (3) parent material, (4) vegetation,

thus putting geological source of the soil in the third place. Dr. R. K. Schofield gave a measurement of the pore space in a Rothamsted soil, this pore space indicating the maximum proportion of the moisture content that was available for crop use. Capillary rise could take place from the sub-soil to root level, but bare surface soil once dried by the sun could never be re-wetted by capillary rise, so that surface evaporation would then be very limited. Dr. B. A. Keen pointed out that, this being so, hoeing and harrowing were useless as a means of conserving moisture in the soil, except by removing weeds and transpiration of moisture thereby. The greatest depth of soil from which capillary rise could take place was about 4½ feet, so that failure of crops—[or the alleged disappearance of certain species of wild plants]—could not possibly be due to lowering of the water table by pumping from wells. Finally, Dr. A. B. Stewart described the experimental work done by the Macaulay Institute, on which it founded its advice to Highland farmers on the manurial treatment of their soils.

Copies of the Report of the Committee, appointed to co-operate with the staff of the Imperial Soil Bureau to examine the soil resources of the Empire, were submitted to the Section. It appears that a good deal of progress has been made in most parts of the Empire in soil surveying, and it is likely that during the next few years provisional soil maps of all these parts will be issued. But to gauge the soil resources of the Empire, data of climate and vegetation have to be taken into account as well as soil data, and in no case are all the sets of data complete. The Committee feel therefore that they can get no further at present.

EDUCATION FOR RURAL LIFE.

This subject was discussed at a joint session of the Educational Science and Agriculture Sections, under the chairmanship of Sir Richard Livingstone of Oxford, the President of the former section. Sir John Russell opened the discussion with a survey of what is being done by utilizing the surroundings of rural elementary schools as the basis of the teaching, and what might be done further if the new centralized senior schools had a sufficient area of land to run as small school estates, and if the teachers were in touch with the agricultural college or experiment station. Mr. Dymond stressed the importance of establishing such senior schools before the school-leaving age was raised to 15 and urged that, during the additional year's schooling, the pupils should be given the opportunity of developing their aptitudes so that, when they left, they should have a vocation in view.

Sir Arnold Wilson, M.P., who arrived by air from the Nazi rally at Nuremberg only a few minutes before he was due to speak, referred to the immense variety of rural occupations and the scope for individual talent, and regretted that many school teachers seemed to regard town as superior to country life. In the case of many boys it was what they learnt out of school that counted most, and he would give a limited amount of discretion to local authorities in releasing boys from school attendance. Let there be no rigid distinction between farm and school—it was all education. The time would come, at 16 or 17 years of age, when, with a background of farming experience, chances of admission to an agricultural school would be readily taken advantage of, and it was then that boys would profit most by schooling. In this he was supporting the views of the Chairman, who, in an impressive presidential address to the Educational Science Section, had emphasized the importance of adult education on the ground that little real knowledge could be acquired until young men and women had a background of experience of life and work. Two other papers lent weight to this contention: Professor Comber urged the importance of University courses of agriculture for the practical farmer, as against the utilitarian smattering of short courses, if he were to take his proper place in the life of the countryside. He also urged the importance of such courses for teachers of the new senior rural schools. Lastly, Mr. H. Morris, Director of Education for Cambridgeshire, advocated the establishment of rural community centres which would provide on a generous scale, not only for the new senior schools, but also for the cultural advance of the adult population of the region.

The final session of the Section was devoted to a consideration of potato diseases. In the course of the discussion, Mr. H. Bryan maintained that healthy seed was the chief factor in successful potato growing, provided the land was suitable and free from potato eel-worm. Degeneration in the potato was due to contamination with virus, spread mainly, if not entirely, by certain species of insects. Dr. Wyllie Fenton afterwards described the vegetation of Scotland as influenced by human activities both for good and evil.

Thus ended the Blackpool meeting, a meeting that left nothing but pleasant recollections, and lively anticipations of the meeting of the British Association at Nottingham next September.

T. S. Dymond

THE AGRICULTURAL EDUCATION AND RESEARCH EXHIBIT AT THE ROYAL SHOW, BRISTOL, 1936

For the purpose of demonstrating to farmers and others interested in agriculture and horticulture some of the problems which are of importance at the present time, the various authorities in the Bristol Province prepared a conjoint exhibit, the different sections of which were co-ordinated and staged by the Ministry of Agriculture and Fisheries. In accordance with the usual custom in this Province, the exhibit appeared under subject-headings irrespective of the authority responsible for its preparation, and, in point of fact, many of the exhibits represented the combined effort of several different authorities.

The exhibit was divided into two main sections, the first being housed in a spacious pavilion measuring 120 × 80 feet, and the second consisting of an outside plot of ground 120 × 65 feet which was devoted to important points relating to farm orcharding and soft fruit growing. Considerable difficulty was experienced with this plot on account of the fact that the massive limestone rock came right to the surface of the ground in many areas.

The following are the main features of the various inside exhibits:—

AGRICULTURE.

(1) *Pig Husbandry.*—This exhibit was based on an investigation of pig husbandry which had previously been carried out in the west of England. Methods of housing were shown with scale models illustrating both indoor breeding and fattening in the intensive house. Typical basic rations were shown, together with the recommended fineness of grinding of meals and the control of water. The investigation had indicated that certain diseases appeared to be responsible for unthriftiness and mortality in the herd, and for these reasons the disease section of the exhibit drew attention to them.

(2) *Liver Rot in Sheep.*—This exhibit showed in a pictorial way the life history of the parasitic worm responsible for the condition, the way in which it multiplied, how it survived on affected ground, and what could be done by way of control.

(3) *Grass Drying.*—In view of the large areas of luscious grass in the West Country, part of the Agricultural Education exhibit was devoted to this important subject. In this exhibit visitors were able to see scale models of various types of grass driers and bales of the final product.

(4) *Injurious Plants.*—The exhibit of noxious plants included approximately fifty specimens of plants poisonous to farm animals and ten specimens of plants which caused taints in milk. Each type of plant was represented by a growing specimen, many of which were in flower, and each plant carried a label giving the common botanical name and a brief descriptive note.

(5) *Eel-worm Diseases of Crops.*—This exhibit was designed to illustrate the type, variety and importance of eel-worm diseases to agriculture and horticulture, the sixteen examples shown being chosen to represent various types of injury caused by eel-worm.

(6) *Organized Instruction in Agriculture.*—The exhibit in this section drew attention to the work of County Agricultural Organizers, to Young Farmers' Clubs and to the various courses of instruction operating throughout the province.

(7) *Soil Surveys.*—The exhibit illustrated relationships which exist between some of the main soil series in the Evesham area and the growth characters of fruit trees (chiefly plums) growing on them.

(8) *Broadcasting.*—Agricultural affairs are of primary importance in the west of England and the B.B.C., through its West of England Programme, has always paid considerable attention to them. The exhibit under this heading drew attention to the various farming talks and country features which form a prominent part of the West of England Programme.

POULTRY.

The main theme of the poultry exhibit was healthy stock. This was emphasized from two angles, viz. management and the facilities available within the Bristol Province for the eradication of disease. By posters and models it was shown that poultry could be kept on the farm under a system which ensured that the land, the crops, the farm stock and the poultry gained the utmost benefit.

DAIRYING.

The dairying exhibit was designed to show the main features of better milk production and utilization. It consisted of four sections, viz. clean milk production, cream and its products, cheese and dairy bacteriology. The clean milk section brought to the notice of milk producers the essential points to be observed in the production and handling of high-grade milk. Special attention was drawn to modern cowsheds and dairy construction, and the best types of utensils and equipment to be used in order to obtain satisfactory

results. In the cream section, the various products which can be manufactured from good quality cream were shown.

The principal varieties of cheese produced in the west of England were displayed in the cheese section, and cheeses made from high-grade milk were contrasted with those produced from milk of inferior quality.

The bacteriological section was concerned with the many factors that may influence the purity of milk and measures that could be adopted to ensure a pure product.

HORTICULTURE.

(1) *Lettuce Diseases.*—This exhibit illustrated three common diseases of lettuces which are of considerable importance to the commercial grower, i.e. Mosaic disease, Botrytis disease, and Ring Spot or Rust.

(2) *Asparagus Culture and Diseases.*—The Asparagus exhibit emphasized the importance of distinguishing between male and female plants, and it proved from experimental work carried out in Worcestershire that over a period of three years male plants produced 90 per cent. more "buds" and 70 per cent. greater crop weights than female plants. The means of distinguishing between male and female plants was illustrated.

The only two diseases of Asparagus of any economic importance in this country, i.e. Rust and Violet Root Rot, were also illustrated.

(3) *Strawberry Problems.*—The necessity for the provision of cross-pollination in the varieties of Oberschlesien and Tardive de Leopold was stressed in this exhibit, whilst attention was drawn to the virus diseases "Yellow Edge" and "Crinkle," both of which diseases are believed to have been important causes of the degeneration of the strawberry plant during the last 20 years.

(4) *Manuring of Soft Fruits.*—This exhibit showed visitors the importance of manuring soft fruits, i.e. strawberries, gooseberries and black currants, in regard to the build up of the plant or bush, regular cropping and longevity of the plantation.

(5) *Cider.*—The exhibit was confined solely to the subject of the bottling of cider, a process which has received much attention in recent years and which has been revolutionized by the advent of the Seitz filter.

(6) *Canning of Fruit and Vegetables.*—Samples of canned products were exhibited along with a number of photographs of the varieties of fruits and vegetables which have been found by research to be the

most suitable for canning. The importance of obtaining fruit of the correct shape and size, particularly in the case of strawberries, was emphasized.

The outdoor horticultural plot was divided into three main sections illustrating in a practical way the following: (*a*) The production, planting and management of farm orchard trees. (*b*) The culture, pruning and diseases of soft fruits and the development of the bush apple tree. (*c*) Strawberry pests and diseases.

A kiosk was provided for literature and visitors were able to obtain copies of the various publications of the co-operating authorities, and the leaflets and bulletins issued by the Ministry of Agriculture and Fisheries.

It was mentioned earlier that the whole exhibit was co-ordinated and staged by the Ministry of Agriculture and there can be no doubt that a central body acting in this way is the most satisfactory method whereby the exhibit can be made uniformly attractive; thus, whatever section of the exhibit one visited, the printing, colouring, background, benching and arrangements were uniform with the other sections, and the various authorities responsible for the various parts of the exhibit are all appreciative of the valuable services rendered by the Ministry of Agriculture and Fisheries in this connection.

Unfortunately, the torrential rain on most days of the Show deprived those people responsible for the exhibit of some of the reward they might have received for their efforts.

A. W. LING.

ROTHAMSTED CONFERENCES, 1936

Three conferences were held at Rothamsted in 1936 dealing with Electricity, Bees, and Barley respectively. Full reports of the first two are available as Rothamsted Conferences Nos. XXI and XXII.

"The Use of Electricity in Agriculture" was discussed at a meeting held on 29th January under the chairmanship of Sir Bernard Greenwell, Bart. A number of valuable papers were presented, to which justice can scarcely be done in a brief notice. Those who are considering the question of electrifying their farms will find much authoritative information in the published report. The position of rural electrification illustrated from conditions in the West Midlands was set out in a comprehensive paper by Mr. H. M. Harvey of the Shropshire, Worcestershire and Staffordshire Electric Power Company. He dealt at some length with the problem of supplying isolated

farms from neighbouring high tension lines and showed the necessity for some form of standing charge to meet the capital outlay. This point was referred to from different points of view by other speakers, and there is no doubt that even now farmers feel that they are on a somewhat different footing from other consumers. It was pointed out that usually the standing charge amounts to the equivalent of about 6d. per unit for lighting, a figure which is not unreasonable. At Rothamsted where a complete electrical system is installed on the farm the standing charge amounts to less than ½d. per unit consumed. Dealing with the development of electricty in various types of farms, Mr. Harvey showed that it was the specialist dairy and poultry farm that lent itself easiest to electrification, for such farms are frequently near large centres of population and are also run on something approaching factory lines. Passing on, he gave detailed information on the uses of electricity on different classes of farms, and the units consumed in carrying out certain typical farm operations.

Mr. F. E. Rowlands followed with a paper on "Electric Motors for Farm Machinery." The advantages of electric power on the farm are well known and admitted, and Mr. Rowlands gave it as his opinion that where current could be obtained at not more than 2d. per unit, electric power was economic for farm use. He went on to describe the various types of motors adapted for farm work, their maintenance, and output under average conditions. The electric wiring of farm buildings was dealt with by Mr. C. A. Cameron Brown, who pointed out that sound design, good materials and skilled workmanship were in the long run more important than first cost. The Rothamsted farm had been electrified to compare electric motors and oil engines as sources of power in farm operations. Mr. G. H. Cashen gave an account of these trials and showed that the power and overhead costs for threshing was 16·2d. per hour for electric motor and 19·5d. for tractor; the corresponding figures for grinding being 8·29d. for motor and 8·02d. for Diesel engine. At the time of the trial electric power cost 1·42d. per unit including the fixed charge; it has since been reduced.

On 26th September a well-attended conference met to hear papers on "The Diseases of Bees." This was the third conference dealing with apicultural subjects, and was of special interest in that a wide geographical field was covered. Dr. H. L. A. Tarr gave the results of three years' work on brood diseases carried out at Rothamsted with the support of the Bee Keepers' Associations. The most prevalent of these diseases in England is American Foul Brood. Dr. G. D. Morrison of Aberdeen then described his work in Scotland

on Bee Paralysis and its diagnosis. Valuable papers were also contributed by Dr. O. Morgenthaler of Liebefeld, on "Bee Diseases in Switzerland," with special reference to Foul Brood and the successful system of insuring against it worked out by Dr. Leuenberger. Striking success has attended the methods adopted against American Foul Brood, but European Foul Brood is undoubtedly increasing in Switzerland and calls for additional control measures. "American Experience with Foul Brood" was summarized in a paper by Mr. J. I. Hambleton of the United States Department of Agriculture. In the discussion, the new scheme of insurance against Foul Brood in Great Britain was described.

The third conference on "Malting Barley," at which growers are given the opportunity of discussing the grading of their samples with a committee of expert barley valuers, was held on 2nd December. A record number of samples was received and the proceedings followed the lines laid down on former occasions. Mr. H. M. Lancaster, a member of the Valuation Committee, gave an interesting paper on "The Problems of Barley Valuation," and compared the samples of 1936 with those of the previous year.

Two informal conferences were held during the year between the Rothamsted staff and members of special agricultural bodies. On 6th February a meeting was held in London at which county organizers and the staffs of the sugar factories met to discuss the results of the manurial experiments on sugar beet carried out in 1935. On 15th October members of the Potato Marketing Board met at Rothamsted to discuss "The Blackening of Potatoes in Cooking," with special reference to a scheme for studying this fault and collecting information likely to throw light on its incidence.

H. V. Garner.

YOUNG FARMERS' CLUBS EVENTS DURING 1936

Conference on Young Farmers' Clubs.

The Conference was arranged by the Carnegie United Kingdom Trust, with the approval of the Ministry of Agriculture and Fisheries, to consider the importance of the Young Farmers' Club movement as an aid to education in rural districts, to encourage the formation of such clubs in all counties in England and Wales, and to submit to County Councils the desirability of the principle of direct annual grants in aid to the N.F.Y.F.C. as a part of their expenditure on agricultural education. Mr. Walter Elliot, the then Minister of

Agriculture, spoke in support of the movement, and stated that the Government would provide 60 per cent. of any contribution made by County Councils.

County Alderman Sir Percy Jackson, LL.D., J.P. (Vice-Chairman of the Carnegie United Kingdom Trust), presided, and those present included representatives of the Dominion Governments, Ministry of Agriculture, Scottish Education Department, Ministry of Agriculture for Northern Ireland, Pigs Marketing Board, Agricultural Colleges and University Departments of Agriculture, Rural Community Councils and representatives of 50 County Councils of England and Wales.

The Show Season.

The number of Agricultural Societies that cater for young farmers' stock judging contests and classes for club stock at their annual shows increases every year, until now there are very few without one or both these classes.

With the exception of the London Dairy Show, these were formerly largely confined to the summer months. But the inclusion of other types of animals than dairy cattle has extended the young farmers' show season into all four quarters of the year. In 1936, the Shire Horse Society for the first time staged a competition at its show in February. This attracted 40 individual entries. This year the Society has extended the contest to include teams as well as individuals.

The Bath and West Society has for some years been most generous in its treatment to young farmers, providing, at its annual show, three classes for stock judging—senior, junior and novice—and also a class for sheep shearing. No entry fees have been charged and the competitors have been given a good tea at the close of the competitions.

At the Royal Counties and Sussex Combined Show three competitions were arranged on three successive days, namely for cattle, pigs and poultry judging. The entries in all three classes were large.

Y.F.C. Stock Classes at most agricultural shows have been well filled. On one or two occasions the number of cattle exhibited by clubs has exceeded the total number of all cattle in other classes.

An improvement in showmanship, and in the preparation of cattle for the ring, were noted at several shows.

The Royal Show.

The R.A.S.E. again gave great encouragement and assistance, and the facilities granted in both Y.F.C. events brought the club

movement into considerable prominence. Teams from five countries competed in the International Stock Judging Contest as in 1935, with the following result:—1, England; 2, U.S.A.; 3, Scotland; 4, Wales; 5, Northern Ireland.

On the afternoon of Thursday of show week came the parade of club cattle from the counties of Wiltshire, Somerset, Gloucestershire and Devon. There were over 130 exhibits in beef and dairy classes, accompanied by County and Club Flags. This was a very impressive spectacle and was described by the press as "one of the most striking displays of high quality farm live stock seen on any show ground this season."

Presentation of awards to the winners of the stock judging contest and of the Y.F. stock classes was made by the President, Sir Merrik Burrell.

THE LONDON DAIRY SHOW.

Cow Judging Contest.—Nineteen counties were represented. Compared with previous contests it may be said that although the rings of cattle demanded fuller knowledge, competitors' work maintained a high standard. The Northern teams lost their supremacy this year, the first three being from Southern Counties. No. 1 individual was, however, a Northumberland boy.

The final team results were:—1, Hampshire; 2, Somersetshire; 3, Buckinghamshire.

The judges, in commenting on the sound way in which reasons were given, pointed out that the standard in these contests improves each year.

Poultry Judging Contest.—Six Club teams competed, three from Somerset being placed 1st, 2nd, and 3rd. Again, the highest individual score came from Northumberland, a girl of 13 years who placed all the birds in the same order as that decided on by the judges. Results:—1, Farrington Gurney "B"; 2, Farrington Gurney "A"; 3, Mid-Somerset.

BEEF CATTLE JUDGING, SMITHFIELD.

The 1936 contest again showed an increase, eighteen teams competing, fifteen of which consisted of past and/or present Y.F.C. members. A team from Northumberland were the winners, with Sodbury Vale (Glos.) Y.F.C., and Somerset, second and third respectively. John Pattison was the highest individual scorer, with R. Moore No. 2, both of Wansbeck (Northumberland).

With three individual champions at London contests, 1936 has been a record year for Northumberland Y.F.C.

At the Christmas Fat Stock Shows, increased facilities were offered to Y.F.C. both for stock judging and for the exhibition of their stock. Entries in most cases were large.

SILVER CHALLENGE SHIELD COMPETITION.

Two Silver Challenge Shields are awarded annually by the N.F.Y.F.C., one for senior and one for junior clubs. They are for all-round efficiency.

Last year the senior shield was won by Bashall Eaves (Yorks.), with Steyning (West Sussex) the runners-up.

Goodmayes (Essex) were the winners of the junior trophy. The Lady Northcliffe Bee Cup was won by the Hornsey High School for Girls.

MANUAL PROCESSES.

While these do not play such a spectacular part as stock judging, they are an important feature of Y.F.C. activities, and are becoming more and more popular, particularly in clubs which are well established. Several county agricultural committees have arranged classes for instruction in rural crafts in connection with Y.F.C.s.

O. W. D.

REVIEWS

Agricultural Botany—Theoretical and Practical. By John Percival, M.A., Sc.D., F.L.S. Pp. xiv + 839. Eighth edition, revised, with additional matter and illustrations. (Duckworth.) Price 18s.

This has been the standard textbook on agricultural botany for over thirty-five years, and there is little change in its method of presentation. The first 300 pages are devoted to an exposition of the principles of pure botany, but the examples are drawn mainly from farm plants. The next 250 pages are concerned with the special botany of farm crop plants; then follow sections dealing with weeds of the farm and farm seeds. Pages 687-778 are devoted to fungus diseases, and pp. 779-818 to bacteria. There is a very good index.

The additional matter relates chiefly to cell division and Mendelism, in previous editions dealt with rather cursorily. It is stated that this edition has been revised, but the revision has not been carried out very drastically, with the consequence that in many respects the book does not give a true picture of the present state of either botany or agricultural botany—if the distinction be permissible. The first part of the book can be criticized on many grounds, for the teaching of botany has made great progress since 1900. It is surprising to find no mention of the importance of boron and manganese in plant growth, nor of the influence of length of day on flowering.

But it is the "agricultural" part of the work which is most disappointing, for it is hopelessly out of date, despite its "revision." The section dealing with sugar beet, one of the most important arable crops in many districts, is entirely inadequate and inaccurate. The only varieties mentioned are Vilmorin's Improved, Knauer's Imperial and Klein-Wanzlebener. It is stated "Average seasons in the British Isles are probably too damp for successful cultivation of this crop, although fair yields of roots with good sugar content have been grown for experimental purposes during the last two or three somewhat dry seasons" (p. 369).

The details concerning retting of flax (p. 398) are in need of revision. There is no mention of marrow-stem kale amongst cruciferous plants. Recent progress in the classification of Red Clovers, and the importance now attached to "strain" receive no mention. The value of White Clover is dismissed with the words: "It is sometimes grown alone for sheep food, but its chief use is in mixtures for laying down pasture for grazing purposes" (p. 432). There is no mention of New Zealand White Clover. It is stated (p. 444) that Yellow Lupin is the species most generally grown as a farm crop. The varieties of cereals need bringing up to date. Plumage-Archer and Spratt-Archer barleys are mentioned, but not described, though they are distinct and more widely grown than any other two varieties. New varieties of wheat, however, receive more space than in previous editions, though the Swedish wheats are not mentioned.

The section dealing with grasses seems to be identical with that which appeared in the fourth edition, published in 1910. One would have expected that in a revised edition the tremendous developments which have taken place since the war in the study of grasses would have received at least some attention. But we look in vain for mention of the different types of Cocksfoot, Rye-grass and Timothy, which are so important in modern agriculture; for mention, even, of Pasture Analysis, let alone how to set about it; for mention of the "simple seeds mixture" hypothesis, whilst the now discredited "ground-covered" thesis of Stebler and M'Alpine receives several pages. The section

dealing with farm seeds is likewise out of date, for no mention is made of the Seeds Act, and the sources of supply of several of the seeds mentioned in the text have changed since the chapter was written.

Part VII, which deals with fungus diseases, was perhaps adequate twenty years ago, but no mycologist would agree that the information given represents the position of mycology to-day. Apart from scientific inaccuracies, the text is misleading to the "practical" man; for example, the formalin treatment of seed wheat against bunt is not correctly described according to present-day ideas, and the impression is given that copper sulphate and formalin are the only agents available for use against smuts.

It is a great pity that this book has not been properly revised and brought up to date. There is nothing to take its place, but in its present form it cannot be unreservedly recommended.

D. H. R.

The Apples of England. By H. V. Taylor. Pp. 266. (London: Crosby, Lockwood & Son.) 1936. Price 21s.

This book, which is modelled on different lines to previous works on apples, will appeal to all who are interested in the "fruit of fruits," whether growers on a small or large scale or only consumers. In the chapters of Part I the author gives a clear and very readable account of the history of the apple in England, and follows with chapters on the morphology of varieties, together with a chapter in which the genetics of the apple are discussed in a simple and enlightening manner. Deserved tribute is paid to the many raisers of new varieties, particularly those who in more recent years have carried out systematic crossing, although the majority of our apple varieties are chance seedlings—the fortuitous outcome of nature's own handiwork.

When one turns to Part II, which is mainly occupied by descriptions of varieties, one realizes that the author has covered a wide field in his observations. Many interesting and almost forgotten kinds are described, but it is difficult to understand why "Blood of the Boyne," described as being "grown only in Ireland," should find a place in a list of apples of England, especially when so many well-known English varieties are omitted. One misses, for instance, the largely grown Cockpit, considered by Yorkshire housewives to be the finest sauce apple.

Typographical errors are few: "Sweet Alfred" (p. 50) should read "Sweet Alford" and for "Royal Show" (p. 230) read "Royal Snow."

The book is well worth the attention of fruit growers but the price places it beyond the man of small means. Halve the price, cut out the coloured plate and most of the other illustrations, which are little but "powder and lipstick," and the value of the book would not be impaired, while its acquisition would be within the means of even the cottager and smallholder.

G. T. M.

A Practical Course in Agricultural Chemistry. By Frank Knowles, F.I.C., and J. Elphin Watkins, B.Sc., Ph.D., A.I.C. Pp. vii + 188, with 21 text figures. (London: Macmillan & Co.) 1937. Price 10s.

This book will be welcomed by all teachers of agricultural chemistry, as there has not been published for many years any book of practical work from the modern aspect. Most teachers, like the authors, have had to distribute to their students typed sheets of instructions and consequently a book of this nature has become very necessary. Although primarily written for degree

and diploma students in agriculture, horticulture, and dairying, the book contains sufficient elementary experiments and quantitative exercises for it to be used by less advanced students, such as those taking a college certificate course. As most of the substances dealt with in the book are met with in ordinary agricultural practice, the student should become interested in the subject and not feel he is working with materials which will be of little use to him in the future—this is particularly important with an applied science such as agricultural chemistry. A very valuable feature of the book is the short theoretical explanations which are given before the experiments are described.

The first two chapters deal with soils, fertilizers and manures. Many recently introduced estimations are given, amongst which may be mentioned the sulphur dioxide method for the estimation of carbon in soils and the "pipette" method for mechanical analyses.

Then follows a chapter on "Plant and Animal Bio-chemistry" in which experiments on the carbohydrates, fats, waxes, sterols, lipins, proteins and the plant pigments are described, a previous knowledge of elementary organic chemistry being assumed. A few analyses of eggs and feathers are included which will be of interest to poultry students.

The feeding stuffs are adequately dealt with in the next chapter. The treatment here is very up-to-date, including the determination of the blue value of cod-liver oil and the "mineral" ingredients in feeding stuffs.

The next chapter dealing with "Dairy Products" is perhaps the best in the book and should be invaluable to dairy students. A good feature of this section is the mention of the various Acts relating to the sale of dairy products, a knowledge of which is essential to the present-day student. The freezing point of milk and the phosphatase test for pasteurized milk are described. It is suggested that the section on milk enzymes should be modified in the light of recent work. For example, test B of Kay and Graham for efficiency of pasteurization might have been included under the description of the phosphatase test.

The last two chapters deal with "Water Analysis" and "Insecticides and Fungicides." The inclusion in the latter chapter of methods for preparing small quantities of the more important insecticides and fungicides in the laboratory should prove particularly useful to the student.

The book as a whole can be thoroughly recommended both to students and analysts working in agricultural chemistry. The methods of analysis given are reliable, and the work brings together many estimations which are widely scattered throughout the literature.

To sum up, the book is well printed and bound but at the price is too expensive for the average student. It is suggested that the production of a cheaper edition, bound in paper covers and printed on other paper, might be considered by the publishers.

T. O. W.

The Study of the Soil in the Field. By G. R. Clarke, B.Sc., M.A. Pp. 140, with diagrams. (Oxford University Press.) Price 5s.

This little book is the first of its class to be published in this, and as far as the reviewer knows, in any other country, which gives practical details for the field study of soils on modern lines. In the short space of five chapters the author presents solid information on how to choose a site for making an examination of typical soil, how to set out the information in an orderly manner, how to sample the soil for subsequent laboratory examination, and how to take a "monolith" or "permanent section" for the museum.

Emphasis is laid on the necessity for making the profile description as complete as possible and with this end in view, careful explanations of the meaning of the numerous terms in soil jargon are given. Only general directions for procedure in surveying and mapping soils are suggested, for anything of a detailed nature is practically impossible, since the knowledge required to make a competent surveyor can obviously be acquired only in the field. In the last part of the book a comparison of systems of classification and mapping employed in various countries is made, bringing out clearly the relation in which the British system stands to those of other parts of the world.

On the question of soil colour, a difficulty which every field worker encounters, is summed up in a sentence on p. 55—"The observer must make what colour description he can devise to give a general indication."

Anyone engaged in surveying is well advised to read this little book and digest it carefully, for nowhere else is the information to be obtained so readily, if at all ; not only soil workers themselves but those engaged in allied sciences will find much to interest them. Doubtless it will be the forerunner of further editions, for in the progress of field pedology rapid strides are being made.

The publishers are to be commended for excellent lay-out, clean type and neat pocketable size.

W. M. D.

Profit from Fertilizers. By H. V. Garner, A. H. Hoare, H. C. Long, R. G. Stapledon, F. Rayns and T. Wallace. Foreword by Viscount Bledisloe, P.C., G.C.M.G. Pp. 171, with 20 illustrations. (Crosby, Lockwood & Son, Ltd.) 1936. Price 7s. 6d.

This book contains eight chapters, each dealing with a different aspect of fertilizers and manuring and contributed by a person recognized to be an authority in his own particular branch. Starting with the more general aspects of the principles of plant nutrition and the nature of present-day fertilizers the story passes on to deal more specifically with the manuring of special classes of crops, viz. grass, arable, fruit and garden crops.

In a country such as Great Britain with its almost unlimited capacity for consuming the products of the land the book should prove an incentive, to the thoughtful farmer at any rate, to increase his output both in quality and quantity. Unfortunately, as is pointed out in the foreword, "many of our land cultivators use fertilizers in but little quantity, if at all, and when they do, pay but little attention to the manurial requirements of the soil and its intended product." Anyone associated with advisory work realizes the truth of this paragraph. It is hoped that if this book has the circulation which it merits, it will do much to dispel this condition of ignorance, which in so many instances is born not only of apathy but frequently of an antagonism towards so-called "book knowledge."

The printing and general arrangement are good and the type bold and easily readable. The illustrations strike rather a modern note. Unfortunately, a few give the impression of being lop-sided, such as, for example, that showing the effect of potash on fruit trees facing p. 132. Some of the pictures deserve a little more explanation, such as, for instance, that facing p. 132, where some remark about the lay-out of the plots would make it clearer to readers unfamiliar with the arrangement of the latin square.

The book winds up with four short appendices dealing with the use and purchase of fertilizers and the effect of boron in treatment for certain diseases of plants. Why manganese is not mentioned as well is not explained.

W. M. D.

Sheep Farming. By Allan Fraser. Pp. 174, 24 illustrations in half-tone. (Crosby, Lockwood & Son, Ltd.) Price 7s. 6d.

Those persons who are really interested in the subject of sheep farming will find that this is a difficult book to put down ; it is written in a clear and lucid style, the subject-matter of not one single page makes "heavy reading," and the many references to personal experiences sustain one's interest throughout.

In his foreword to the book, Sir John Orr points out that the writer has wisely concentrated on those aspects of sheep farming with which he is most familiar. The book is written from the standpoint of one who has had a very wide practical experience of sheep farming in Scotland, and the types of sheep referred to are mainly the Cheviot, the Scots Blackface, the Half-bred, and the Greyface. This in no way detracts from the value of the book, for the standard of efficiency in sheep husbandry is higher in Scotland than it is in England, and Scotch-bred sheep are to be found in very many English counties to-day.

The chapters of the book that are of outstanding interest and value are those that deal with Lambing, The Young Lambs, and Rearing Lambs. These chapters could only have been written by one who had endured days and nights of hardship and worry during several lambing seasons. Diseases of ewes and lambs are dealt with in two chapters in a most thorough but non-technical manner, although it is surprising to find only a very brief reference to Lamb Dysentry. The subject of Dipping is dealt with in Chapter 11, it would have been better if the author had made a clearer reference to the existence of single and double dipping areas. Some of the author's views on the question of teg fattening, e.g. the necessity for cutting roots and the essentiality of feeding hay, are not in agreement with those held by some successful farmers in the south of England.

The general tone of the book is perhaps somewhat opinionative, but it is obvious that the author has had such extensive experience that he is justly entitled to have definite views.

The attractiveness of the book is enhanced by the inclusion of twenty-four excellent illustrations in half-tone.

J. F. H. T.

Great Farmers. By Professor J. A. Scott Watson and May Elliot Hobbs. With a foreword by the Right Hon. Walter E. Elliot. Pp. 287, illustrated in half-tone and line. (Selwyn & Blount.) Price 12s. 6d.

It is quite possible that in years to come Mr. Walter Elliot may be remembered more for the fact that he wrote a foreword to *Great Farmers* than for his strenuous efforts on behalf of British agriculture. This is a book that will endure, and read in conjunction with Lord Ernle's *English Farming, Past and Present,* it gives a picture of the development of farming in these islands that no other book can provide.

The authors have interpreted the term "farmer" very widely. They describe the work of drainers, engineers, scientists, stockbreeders, salesmen, journalists and others who have forwarded the cause of agriculture. Not the least interesting part of the book is devoted to a lengthy account of the development of the great agricultural societies like the Highland and Agricultural Society, the Royal Agricultural Society and the Bath and West Society. The familiar names of Bakewell, Bates, Parkes, Smith, Arthur Young, re-appear in these pages, but it must not be imagined that this is a re-hash of dead biographical mutton. There is not a dull moment in the book, and the

reader becomes enthralled with the records of many men, previously known only to a limited circle, who have advanced the art that was their life's work.

It is impossible here to give any extracts that will show the interest and quality of this book ; it must be read to be properly appreciated. Practically every aspect of agriculture is covered except the political. It is significant that although over seventy pages are devoted to the activities of stock-breeders, the only reference to poultry occupies about a line and a half. Stockbreeders, indeed, receive a great deal of attention, but we should like to know more about the improvers of the crops of the farm, without whose efforts the stockbreeders would have been helpless. Shireff receives nearly two pages, but Le Couteur is not mentioned.

The book is written in an interesting and enthralling manner, and it reads very evenly. Some of the names of places and individuals have been incorrectly spelt, and most of them are mentioned in an *erratum* slip. But on p. 67 "1777" should read "1877" ; the dust cover should be withdrawn, for it renders Sanders Spencer as Sanders, Spencer, and spells James Caird's name wrongly.

D. H. R.

A Survey of the Agricultural and Waste Lands of Wales. Edited by R. G. Stapledon, C.B.E. Pp. xv + 143, and 1 large folding map. (Faber & Faber.) Price 15s.

The scope of this book is well expressed in the title—it is a large-scale survey of the vegetation of Wales with the object of providing data upon which "proposals may be made for the better utilization of the land." The book is divided into four parts. There is a General Introduction by R. G. Stapledon, an account by William Davies of the Grass-lands of Wales, which occupies the body of the work, a brief Soil Survey of Wales by G. W. Robinson, and a short Soil Survey of Sandy Coastal Areas by G. W. Robinson and Evan Roberts.

Professor Stapledon's short but stimulating introduction is a reiteration of his belief in land reclamation as a national tonic, and of the reliability of vegetational surveys in the demonstration of agricultural potentialities. Mr. William Davies's memoir is an admirable example of the way in which vegetational surveys should be carried out, and it should be studied by all those who are in any way interested in ecology. An interesting point is his preference for autumn in carrying out such surveys, on account of the colour contrasts between the various plant associations. This section of the book is not everybody's meat: it needs hard reading and more than a nodding acquaintance with botanical terms to be properly appreciated, so that it will probably not be read by those who most ought to study it, namely landowners and legislators. Still, even these ought to be able to understand the significance of the large-scale map of the whole of the grass-land of Wales which occupies a pocket at the end of the volume. Mr. Davies's survey is important to both the professional botanist (because of its technique) and to the agriculturist and land improver (because of its conclusions).

In the Soil Survey sections a brief account is given of this branch of work, together with certain conclusions applicable to North Wales. A coloured soil map of Malltraeth Marsh, near Caernarvon, is included, and another of Traeth Manor and Morfa Harlech. There is a good index, and the printing and binding are up to the high standards expected of Messrs. Faber and Faber.

D. H. R.

BULLETINS AND REPRINTS

Agricultural Education authorities are invited to send copies of their publications to the Editor for inclusion in this section.

UNIVERSITY OF BRISTOL.

Agricultural Advisory Office, 22, Berkeley Square, Bristol.

"The Financial Aspect of Milk Production" (Bulletin No. 15), by C. V. Dawe, and J. E. Blundell.

"Winter Feeding for Milk Production," by C. V. Dawe, and J. E. Blundell.

UNIVERSITY OF CAMBRIDGE.

School of Agriculture.

Memoir No. 8. This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible the contributions made by members of the Staffs of the School of Agriculture and its Associated Institutes to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published. Each summary is compiled by the author of the paper and is presented, so far as the subject-matter will allow, in a non-technical form in order to be of value to the general body of farmers interested in the more recent developments of agricultural scientific research in general, and of the activities of this Department in particular.

Requests for further information or criticism arising out of the summaries should be referred to the individual author concerned; criticisms and suggestions for the improvement of the Memoir itself should be addressed to the Librarian of the School.

UNIVERSITY OF EDINBURGH.

Edinburgh and East of Scotland College of Agriculture,
13, *George Square, Edinburgh.*

Calendar for 1936–37.
Guide to Boghall Experimental Farm, 1936.
Report on the work of the College for the year ending 30th Sept., 1936.
The Farm of Shorthead.

Institute of Animal Genetics.

"The Genetics of the Pig," by A. D. Buchanan Smith, O. J. Robinson, and D. M. Bryant.

This is a book of 160 pages, bound in stiff boards, reprinted from *Bibliographia Genetica* XII, 1936. It provides a mass of information collected into 14 chapters as follows:—1. Chromosome Number, II, Colour; III, Hair and Skin; IV, Physiological Chapters; V, Disease Resistance; VI, Mental Traits; VII, Sex; VIII, Abnormalities and Defects; IX, Anatomy and Conformation; X, Productive Qualities; XI, Methods of Improvement; XII, Figures; XIII, Bibliography, XIV, Index.

HANNAH DAIRY RESEARCH INSTITUTE, KIRKHILL, AYR.

Seventh Annual Report for the year ending 31st March, 1936.

HARPER ADAMS AGRICULTURAL COLLEGE, NEWPORT, SHROPSHIRE.

College Prospectus, 1936.

Farm Guide, Season 1936.

Report of the Advisory Departments. A Review of Advisory Work in the West Midland Province, 1935–36.

The Work of the Harper Adams Pig Feeding Experimental Station, April, 1935–March, 1936, by C. Crowther and T. S. Wright.

SEALE-HAYNE AGRICULTURAL COLLEGE, NEWTON ABBOT, DEVON.

Department of Plant Pathology. Pamphlet No. 46. Twelfth Annual Report for the year ending 30th Sept., 1935.

"Financial Results on certain Devon and Cornish Farms for the year 1934–35," by R. Henderson.

Farmers' Report No. 12, Dec., 1936.

SOUTH-EASTERN AGRICULTURAL COLLEGE, WYE, KENT.

Department of Economics. Report No. XXIV. "Financial Results on the College Horticultural Holding," 1931–32 to 1934–35, by James Wyllie. Price 2s.

Department of Economics. Report No. XXIII. "Investigation into Farming Costs of Production and Financial Results," by James Wyllie. XVII. "Financial Problems in Pig Keeping," by James Wyllie.

The Journal, No. 38, July, 1936. The contents include:—"The Microscopic Examination of Cattle Foods," by S. T. Parkinson; "The Consolidation of some Loam Soils and the effects upon the Growth and Yield of Cereals," by Cornelius Davies and G. B. Smyth-Homewood; "Some Impressions of British Soils," by Professor C. F. Shaw; "The Control of Apple Scab, Allington Pippin and Newton Wonder, 1935," by W. Goodwin, N. H. Pizer, E. S. Salmon and W. M. Ware; "Two New Varieties of Hops": "Fillpocket" and "Quality Hop," by E. S. Salmon; "The Downey Mildew of the Hop in 1935," by E. S. Salmon and W. M. Ware; "The Cladosporium Disease of Hops," by E. S. Salmon and W. M. Ware; "The Manuring of Hops," by A. H. Burgess; "Hop Drying—Air Supply and Heaters," by A. H. Burgess; "Pyrethrum" by S. G. Jary; "Investigations on the Insect and Allied Pests of Cultivated Mushrooms—VI," by S. G. Jary and J. H. Stapley; "Almond and Peach Buds Attacked by a Gall Midge in Greece," by H. F. Barnes; "Investigations on the Insect and Allied Pests of Cultivated Mushrooms—VII," by M. D. Austin and R. S. Pitcher; "Investigations on the Insect and Allied Pests of Cultivated Mushrooms—VIII," by R. S. Pitcher; "Three Weevils of the *Genus Rhynchites* Injurious to Fruit," by Sholto W. Rolfe; "Gall Midges (*Cecidomyidae*) whose Larvæ attack Fungi," by Joan A. T. Anderson; "Food Costs in Relation to Milk Yield," by A. L. Jolly; "The Expenditure of Lime in the carrying out of Agricultural Crop Trials," by N. L. Tinley; "Miller's Offals," by V. C. Fishwick; "Newer Methods of Estimating the Hygienic Quality of Milk," by H. Barkworth; "Agriculture and the Mathematician," by H. B. Bescoby; "Agricultural Meteorological Scheme Precision Records on Wheat, 1934–35," by A. F. Howell and R. M. Harrison; "Meteorological Observations, 1935," by J. L. Hunt; "Plums—Notes on their Pollination, Order of Flowering of Varieties and Insect Visitors to the Blossom," by Cecil A. Hooper; "Additional Note on Cereal Growth in a Consolidated Loam," by Cornelius Davies and G. B. Smyth-Homewood; "The Technique of Van Oijen's (Modified) Test," by H. Barkworth; "The Preservation of Fencing Materials," by S. C. Bunce; "A Note on the Scion Rooting of Apple Varieties," by R. T. Pearl; "The Nomenclature and Terminology of Soils," by Rev. S. Graham Brade-Birks; "The Geology of the Soil," by Rev. S. Graham Brade-Birks.

The Journal, No. 39, Jan. 1937. This gives an account of the work of the Advisory Departments.

ESSEX COUNTY COUNCIL.

East Anglian Institute of Agriculture, Chelmsford.

Calendar, 1936–37.

"On Lordship Farm, Writtle," by Alfred Hills. May, 1936.

ISLE OF MAN.

Board of Agriculture, Knockaloe, Peel.

The Manx Journal of Agriculture, Vol. III, No. 2, July, 1936; Vol. IV, No. 1, Jan., 1937.

Report of the Board of Agriculture for the year ending 31st March, 1936.

Report of the Agricultural Organizer and the Financial Statements of the Board as audited.

KENT EDUCATION COMMITTEE.

Agricultural Offices, Springfield, Maidstone.

"The Romney Marsh Problem," by G. H. Garrad.

NORTHUMBERLAND COUNTY COUNCIL.

Agricultural Education Committee, 8, Westmorland Road, Newcastle-on-Tyne.

Bulletin No. 49. "Guide to Cockle Park Agricultural Experiment Station, 1936, by J. A. Hanley.

SHROPSHIRE COUNTY COUNCIL.

Agricultural Education Office, College Hill, Shrewsbury.

Shropshire Agricultural News, Vol. II, Nos. 3, 4. Vol. III, Nos. 1, 2, 3.

WILTSHIRE COUNTY COUNCIL.

Polebarn House, Trowbridge, Wilts.

Advisory Report on Pig Husbandry and Experiment on Poultry Feeding, by W. T. Price and A. W. Ling.

WORCESTERSHIRE COUNTY COUNCIL.

Department of Agricultural Education, County Buildings, Worcester.

Agricultural Quarterly Chronicle, Vol. IV, Nos. 3, 4; Vol. V, No. 1.

MINISTRY OF AGRICULTURE AND FISHERIES.

"Scientific Principles of Poultry Feeding," Bulletin No. 7, by E. T. Halnan.

"Rotation of Crops," Bulletin No. 85. Price 9d. net.

"Beans," Bulletin No. 87. Price 2s. net.

"Allotments," Bulletin No. 90. Price 1s. net.

"Insect Pests of Crops, 1932–34," Bulletin No. 99. Price 1s. net.

"Methods of Hedge and Tree-stump Clearing," Bulletin No. 101. Price 9d. net.

DOMINION OF CANADA.

Report of the Minister of Agriculture, year ended 31st March, 1935. Price 25 cents.

AIR MINISTRY.

Meteorological Office.

Weekly Weather Report for the period 4th March, 1934–2nd March, 1935. Fifty-seventh Year, Vol. LI. New Series. Price 7s. 6d. net.

LINGNAN UNIVERSITY.
Canton, China.
Lingnan Science Journal, Vol. XV, No. 4. (Issued 17th Nov., 1936.)

We have received from Messrs. Ballière, Tindall & Cox, 7–8, Henrietta Street, Covent Garden, London, W.C.2, what is claimed to be the most comprehensive list of current books and periodicals in the English language dealing with agriculture, horticulture, forestry and animal husbandry. It may be obtained free from the above publishers.

REPRINTS.

COMMON, R. H.: "Observations on the Mineral Metabolism of Pullets," *J. Agric. Sci.*, Vol. XXVI, Part 1, Jan., 1936.

FENTON, E. WYLLIE: "The Need of a Permanent Organisation for undertaking Periodic Botanical Surveys of Great Britain," *Scottish Forestry Journal*, Vol. XLIX, Part 2, Oct., 1935.

FENTON, E. WYLLIE: "The Periodicity and Distribution of Algæ in Boghall Glen (Midlothian)," *The Scottish Naturalist*, Sept.–Oct., 1936.

FENTON, E. WYLLIE: "The Problem of Moor Mat Grass," *S.J.A.*, Vol. XIX, No. 2, April, 1936.

FENTON, E. WYLLIE: "The Spread of Bracken (*Pteris aquilina*) in Scotland and its Ecological Significance," *Agric. Progress*, Vol. XIII, 1936.

FENTON, E. WYLLIE: "Some Aspects of Man's Influence on the Vegetation of Scotland," *Scottish Geographical Magazine*, Vol. LIII, No. 1 (1937).

GREEVES, F. N., and MUSKETT, A. E.: "A Temperature Study of Pythium attack on Swede Seedlings," *An. Appl. Biol.*, Vol. XXIII, No. 2, pp. 240–270, May, 1936.

HEDDLE, R. G., and OGG, W. G.: "Irrigation Experiment on a Scottish Hill Pasture," *Journal of Ecology*, Vol. XXIV, No. 1, Feb., 1936.

HODSON, W. E. H., and GIBSON, G. W.: "On *Aphelenchoides hodsoni*, Goodey, attacking Narcissus," *J. of Helminthology*, Vol. XIV, No. 2, June, 1936, pp. 93–98.

HODSON, W. E. H.: "The Lily Thrips (*Liothrips vaneeckei*, Priesner)," *Bull. of Ent. Res.*, Vol. XXVI, Part 4, Dec., 1936.

LAUDER, A., and COMRIE, A.: "The Composition of Heather (*Calluna vulgaris*)," *S.J.A.*, Vol. XIX, No. 2, April, 1936.

LING, A. W., and PEEL, W. R.: "Grass Silage and Silos," *Chemical Engineering Group, Soc. of Chem. Industry*, Dec., 1935.

MITCHELL, R. L.: "Spectrographic Analysis of Soils by the Lundegardh Method," *J. Soc. Chem. Industry*, 18th Sept., 1936.

MITCHELL, R. L.: "The Base Status of Scottish Soils. I, The Effect of Lime on five typical soils from North-East Scotland," *J. Agric. Sci.*, Vol. XXVI, Part 4, Oct., 1936.

MITCHELL, R. L., and ROBERTSON, I. M.: "The Effect of Aluminium on the Flame Spectra of the Alkaline Earths. A Method for the Determination of Aluminium," *J. Soc. Chem. Industry*, 18th Sept., 1936.

PRICE, W. T., and LING, A. W.: "Pig Husbandry—An Investigation conducted in the South-West of England," *Bath and West Society's Journal*, 1935–36.

ROBERTSON, I.: "An Agar and Potassium Chloride Bridge. For Use with Calomel Half-cells," *The Analyst*, the Journal of the Society of Public Analysts and other Analytical Chemists, Oct., 1936.

ROBINSON, D. H.: "The Establishment and Management of Poultry Turf," *Harper Adams Utility Poultry Journal*, Vol. XXI, No. 4, Feb., 1936.

ROBINSON, D. H.: "Plants found in Poultry Pens," *S.J.A.*, Vol. XIX, No. 2, April, 1936.

SMITH, A. D. BUCHANAN: "Breeding Dairy Cattle," *J.B.D.F.A.*, Vol. XLVIII.

SMITH, A. D. BUCHANAN: "Genetics," *The Journal of Dairy Research*, Vol. VI, No. 2, May, 1935.

SMITH, A. D. BUCHANAN: "The Inheritance of Productivity in Farm Livestock," *The Empire Journal of Experimental Agric.*, Vol. III, No. 9, Jan., 1935.

STEWART, A. B.: "Some Soil Problems in Forest Nurseries," *The Scottish Forestry Journal.*

VARAKALU, T.: "Studies in Sugar Cane. II, Performances of Canes as Influenced by Environmental Conditions," *The Madras Agric. Journal*, Vol. XXIV, No. 2, Nov., 1936.

WHITNEY, D.: "Agriculture in the East and South-East of Scotland," reprinted from *Regional Types of British Agriculture*, edited by J. P. Maxton. (G. Allen & Unwin.)

WILSON, A. S. B.: "The Improvement of Rough Hill Pasture by Cattle Grazing," *S.J.A.*, Vol. XIX, No. 4, Oct., 1936.

WRIGHT, N C : "An Inquiry into the Drinking Habits of Children of School Age, with Special Reference to Milk Drinking," The Hannah Dairy Research Institute, *Bull No.* 7, 1936.

NOTES

The Fourth International Grassland Congress will be held in this country during July, 1937. Proceedings start at Oxford on 8th July, the Paper Reading Sessions begin at Aberystwyth on 15th July, and the Tours begin on 18th July, finishing on the 23rd. Particulars and enrolment forms may be obtained from the Joint Secretaries, Agricultural Buildings, Aberystwyth.

AGRICULTURAL PROGRESS

VOL. XIV (Part II). 1937

AGRICULTURAL EDUCATION ASSOCIATION

The object of the Association is the development of agricultural education and research by mutual assistance and advice. It includes county agricultural organizers and instructors, and members of the teaching, research and advisory staffs of agricultural colleges, departments and research stations. The Association was established in 1894, and reconstituted in 1899. Its membership now is about 500.

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AGRICULTURAL PROGRESS

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"... Pater ipse colendi
Haud facilem esse viam voluit ..."—VIRGIL

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AGRICULTURAL PROGRESS VOL. XIV (PART II)

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IN THE BEGINNING: A Series of Articles dealing with the Development of Agricultural Educational and Research Institutions.

2. THE UNIVERSITY OF OXFORD

By J. A. Scott Watson, M.A.
Sibthorpian Professor of Rural Economy

The Sibthorpian Professorship of Rural Economy at Oxford takes its name from the founder. Dr. John Sibthorp was the son of an Oxford professor, took a medical degree and, in 1784, succeeded his father in the Chair of Botany. He devoted himself to the collection, description and classification of plants and had won, before his early death, a considerable reputation as a systematist. He was elected a Fellow of the Royal Society in 1789.

Sibthorp's main study was the plant life of the Eastern Mediterranean region, though he also compiled a *Flora* of his native county. He spent two periods, each of a year and a half, in collecting botanical specimens in Greece, Turkey, Asia Minor, Crete, Cyprus and the Aegean, taking an artist with him, on both occasions, to make drawings of the living plants. Most of the intervening years were spent in classifying and describing his collection.

Unfortunately the hardships of travel broke Sibthorp's health and he died, a few months after returning from his second tour, with his task still uncompleted. His death took place in 1796 at the age of thirty-eight.

Sibthorp bequeathed to the University his books on Agriculture and Natural History, his vast collection of specimens and drawings, and also his freehold estate, a farm situated in the parish of Stanton Harcourt, Oxfordshire.

The ultimate object of his bequest was to endow a Professorship of Rural Economy, but the income was to be devoted, in the first place, to the publication of his *magnum opus* on the Flora of Greece. This was a vast undertaking, for the *Flora Graecae* ultimately ran to ten large folio volumes, containing 966 coloured plates. The cost was enormous and the work absorbed the income from the estate for a period of forty-four years. It was thus not until 1840 that the income was set free, and a Professor of Rural Economy could be appointed.

According to the terms of the bequest the chair of Rural Economy was to be held jointly with that of Botany. It is clear that Sibthorp

did not intend the holder of the office to give systematic instruction in agriculture, but rather that he should devote himself to study and research. He was required to deliver only one public lecture in each University term, but he was to devote a part of the Botanical Garden to a collection of economic plants, and was to spend any available surplus income from the bequest in building up a library of botany and rural economy.

The first Sibthorpian Professor was, of course, the then Professor of Botany, Dr. C. B. G. Daubeny. He was a man of the widest scientific interests as well as of sound classical learning, and he took his duties very seriously. His lectures embodied mainly the results of his own original work, and three series were published in book form. Of the three the best known is the *Lectures on Roman Husbandry*, published in 1857, a scholarly work that may still be read with interest. Daubeny was, however, more than a book scholar and was anxious to ensure that his successor should have opportunity to carry out practical experiments. With this in mind he bought a two-acre field on the outskirts of Oxford and conveyed it to the University. It does not appear, however, that the land was ever used for the intended purpose.

Daubeny died in 1867 and was succeeded in his dual office by Professor M. A. Lawson; there is, however, no record of any agricultural activity on his part. The charitable explanation is perhaps that the teaching of botany and the care of the Botanical Gardens had become a full-time occupation. In any case there is a gap of seventeen years between Daubeny's last lecture and Sir Henry Gilbert's first.

In 1877, before Lawson resigned to take up a post in India, the University decided that, for the future, the Sibthorpian Professorship should not necessarily be held by the Professor of Botany, and when the next opportunity arose a separate appointment was made. The available income, however, amounted to little more than £200 a year, so that a whole-time appointment was out of the question. It was therefore decided to have a visiting Professor, who would deliver a course of twelve lectures annually, who should be appointed for a period of three years but who might be re-elected for a second period.

The first professor under the new scheme was Dr. J. H. Gilbert (Sir Henry Gilbert) of Rothamsted, who occupied the chair from 1884 till 1890. Gilbert naturally confined his lectures to the principles of plant nutrition, the composition of soils, and the feeding of animals, and he seems to have relied mainly upon the Rothamsted data for his subject matter. Some of the elderly dons are said to

have been severely shocked when they learnt that they had an academic colleague discoursing on the subject of manure; but the lectures seem to have been fairly well attended.

When Gilbert retired, in 1890, farming was in a bad way, and the rent of Sibthorp's farm was falling short of the sum needed to pay the professor's salary. Moreover, the tenant required a new set of farm buildings. Hence there was another gap of four years before Robert Warrington was appointed in 1894. He held the chair for three years.

Meanwhile the University did consider a request emanating from the Board of Agriculture, that it should provide some more systematic and continuous instruction in agriculture. A committee was set up in 1891 to consider the matter, and recommended that the functions of the Sibthorpian Professor be enlarged, that an assistant be appointed and that the subject of agricultural science should be recognized as one of the options for the ordinary degree. The Council of the University did not, however, act on the report. Whether the scheme failed to commend itself because it went too far, or because it did not go far enough, does not appear. In any case a favourable opportunity of making a serious start in agricultural education was missed. It would be unfair to suggest that nothing was done, for Oxford gave its help towards providing organized instruction in what was then the University Extension College at Reading, and is now the University of Reading.

In 1896, just before his demission of office, and on the occasion of the centenary of Sibthorp's foundation, Warrington delivered a lecture on *Agricultural Science and its Place in a University Education* and took the opportunity of urging that proper provision should be made for the teaching of agriculture, and that it be recognized as an examination subject. By this time the rent of the old farm had fallen to £137, which sum was clearly insufficient to do anything that was worth doing. A fresh attempt was made to rouse interest, and in 1898 a form of statute was promulgated which proposed to establish an Honours Degree in Agricultural Science. The statute was rejected in congregation by a majority of two, forty-seven to forty-five.

The business was again allowed to rest for eight years, when St. John's College solved the immediate problem by offering to provide the additional funds necessary to pay a full-time professor. Dr. William Somerville was appointed to the new post in 1907. Somerville had been the first Professor of Agriculture and Forestry at Armstrong College and had planned and carried through the early work at Cockle Park. He had passed on to Cambridge as

the first Draper's Professor of Agriculture; and now, after a short spell at the Ministry of Agriculture, he started for the third time in his life to build up a University Department of Agriculture.

Somerville was a man of wide interests and knowledge, and was a leading authority on forestry as well as agriculture. His work on grassland, at Cockle Park and throughout the North of England, had already won him the confidence of the farmer, and indeed few men have done more than he to make the farmer truly believe in agricultural science. He was perhaps a little impatient of "high-brow" academic research. He liked always to see a not-too-distant practical object. But anything that looked like being translatable into farming practice aroused his keen and active interest. He was an excellent lecturer, and spared no pains with his students, whether they were brilliant or the reverse. He followed each man's career with fatherly interest and won something more than the respect of those who sat under him.

Somerville's teaching facilities were very limited and his staff was at first extremely small. Moreover he had to divide his own activities, for many years, between the departments of agriculture and forestry, being responsible for the teaching of forest botany in the latter, which was under the direction of his friend Schlich. He maintained his early interest in grassland and, having no University Farm to manage, he bought, as a private venture, the land on the South Downs which became famous under its well-deserved name of Poverty Bottom. There, when the War broke out, he was in the midst of demonstrating once again the transformation that could be worked with basic slag.

As regards the organization of teaching, Somerville instituted a two-years' course for a Diploma in Rural Economy and also a course for students offering agriculture as a subject in the Final Pass School, i.e. for the ordinary B.A. degree.

In 1912 a private benefaction of ten thousand pounds (by Mr. Walter Morrison of Balliol College) made possible further expansion and especially a much needed addition to the lecture room and laboratory accommodation. The number of students was growing steadily if slowly, and the roll for 1913 was twenty-two.

This year also saw the establishment of the Institute for Research in Agricultural Economics. Sir Daniel Hall was the moving spirit at the Ministry and A. L. Smith, the then Master of Balliol, gave the required support within the University. Thus the Department seemed to be getting well into its stride when the outbreak of war practically emptied it of staff and students alike.

It seemed, however, that the School was in a very fair position

to make a fresh start with the coming of peace. The new buildings had been designed to accommodate sixty or seventy undergraduates. A statute instituting a degree in agriculture was drawn up before the Armistice, and came into operation in 1919. Finally a lease was taken of a farm at Sandford-on-Thames, three miles from Oxford, to provide facilities for teaching and field experiments. The farm, indeed, was a bad one, and not even basic slag was to make it good; moreover it was stocked at a very expensive time and, after making small profits for the first two years, involved the School in several successive and heavy losses; but it served its immediate purpose fairly well.

The Oxford School, like all similar institutions, was crowded out with men in the post-War years. Over two hundred had to be provided for in 1920 and again in 1921, while the degree list for the latter year contained fifty-four names.

Somerville's health gradually gave way after this time, and he retired in 1925; but he left his subject fairly solidly established in the University. The task had taken a hundred and twenty-nine years.

AGRICULTURAL EDUCATION: THE FARM INSTITUTE SCHEME*

By J. C. Leslie,

Principal, East Anglian Institute of Agriculture, Chelmsford

Recent speeches delivered to the Agricultural Committee of the County Councils' Association and the National Farmers' Union by Mr. H. Ramsbotham, M.P., Minister of Pensions, must have given pleasure to all those engaged in agricultural education. It is indeed refreshing to find a re-awakening of official interest in our work. The kind of developments which Mr. Ramsbotham suggested are of such a scale that it appears to me there is need for a complete survey of our work and steps to be taken, to ensure that no particular section of it will receive undue emphasis.

Mr. Ramsbotham's speeches have, in the main, stressed young farmers' clubs and Farm Institutes. No one would seek to minimize the vital part which both of these activities play in the general scheme, but it is, I think, desirable that before the Government is asked to provide substantial sums of money for the extension only of these two sections, a complete scheme of agricultural education should be comprehended and agreed.

Recently the Agricultural Education Association drew up a memorandum on "Systematic Courses of Instruction." This memorandum dealt with the establishment of classes in rural science at senior schools, continuation classes under the charge of science teachers at these senior schools for boys and girls in rural occupations until they were 16 years of age, and organized courses conducted by county agricultural staffs for all those over 16 years of age engaged in the industry. Since that report was issued the Agricultural Education Association was invited to send a small deputation to the Ministry of Agriculture, to discuss with Mr. Ramsbotham the organization of these courses. Mr. Ramsbotham was extremely quick to appreciate their importance and the kind of organization which the Agricultural Education Association had outlined. He promised to use his influence with the Board of Education and the Ministry of Agriculture in an endeavour to bring about such an arrangement.

Having got that part of the scheme agreed, we ought now to consider the further development of our work. From what Mr.

* Paper read at the December meeting, 1936.

Ramsbotham has said it can be assumed that the Ministry of Agriculture is considering a substantial addition to the number of farm institutes. It is reasonable at this stage, therefore, to consider, and if possible agree upon, the true functions of an institute, its economic size, its staffing and its equipment and furnishing, and its relation to the agricultural education scheme, as a whole.

Before any serious addition to the number of farm institutes is contemplated I personally feel that other parts of the service should receive prior consideration. For example:—

(1) County staffs should be increased to cope properly and competently with schemes of work already in hand.

(2) Existing farm institutes should be enlarged to deal with a minimum number of 120 students (Mr. Ramsbotham's expressed idea of the smallest economic number).

(3) The staffing, equipment and furnishings of these institutes should be brought up to the standard required for modern technical instruction.

(4) All research and teaching institutes should be adequately financed.

I have no practical experience of the so-called typical farm institute, if indeed such an institute does actually exist. I have a feeling that there is a fairly widely conceived idea that the main purpose of a farm institute is to train principally manual workers for the industry. This I consider to be wrong, and indeed to be outside the capabilities of any ordinary institute. The functions of a farm institute ought to be concerned mainly with the training of officers and non-commissioned officers for agriculture or, if you like, the leaders of the industry, and not so much in teaching the less responsible workers. Justification for this point of view may be found in the following extract from the "Sixteenth Report of The National Institute of Industrial Psychology":

> "Industry frequently makes the mistake of promoting a highly skilled worker to a 'boss' job just because he has done his own job well. The assumption of the management that technical skill is the only qualification for becoming a supervisor, or manager, has led to many breakdowns."

There has also been some body of opinion that the general education of the farm institute student left much to be desired. In consequence the elementary school system has been criticized. Records, however, show that 70 per cent. of farm institute students have been to secondary schools. In the case of Chelmsford the percentage is over 80. (It is only true to say, however, that two of the best students at present at Chelmsford had no secondary

school education.) It is fairly obvious, therefore, that the type of student seeking instruction at farm institutes is one aiming at a really responsible position in the business of farming, and obviously the curriculum ought to be devised for that type of student.

If we are to have any extension of the farm institute scheme, which is a most expensive one, it is reasonable to expect that along with that extension we should have a proper system of recruitment. The obvious system is through the organized classes, which have already been discussed so fully by this Association. When these courses have been established and a properly organized system of agricultural education is in force, courses at farm institutes should be open principally to those who have attended an organized course of instruction and have passed some approved test of educational attainment and practical skill, or to those who can produce evidence of a good secondary school education plus some practical skill. We shall all agree with Mr. Ramsbotham that courses should not be of shorter duration than one year. In agriculture, however, I think it may be more practicable to have a course extending over two winters, rather than over a full year.

We must agree too, I think, that the Institute in the main should attempt to teach the sciences underlying the practice of all the various branches of the industry, and to demonstrate the application of these principles in modern commercial practice. Obviously, therefore, a bold and sound farming policy will have to be a very necessary complement to the teaching syllabus. In my view the modern institute farm should be so laid out that such enterprises as may be decided upon shall be of a thoroughly economic and commercial size. This would only be possible if some present institute farms were enlarged and their scope widened. I do not believe it is possible to demonstrate properly the application of any scientific principle to modern farming practice unless it is applied on a proper scale. If attempts are made to apply these principles in a non-commercial way, students may go away from the institute with impressions that are altogether wrong. It is with this idea in mind that we are attempting to lay out the farm which we have just secured for the new Chelmsford Institute.

The teaching buildings should provide full facilities for instruction in the sciences of chemistry, physics, botany, zoology, bacteriology, veterinary science, etc. There should be adequate workrooms for students. On the permanent staff there ought to be instructors competent to deal with all these subjects.

I am convinced that whilst students are in residence at a farm institute the bulk of their time should be devoted to working in

laboratories and classrooms, and to studying the commercial management of farm enterprises. I am not against students doing a certain amount of practical farm work. In fact, I believe a limited amount to be desirable. My own experience has shown me that it is unwise for a farm institute, or any agricultural teaching centre, to stress unduly practical instruction, if only for this reason, that where any appreciable number of students have to be handled they tend to behave in much the same way as an army fatigue party. In other words, six men go to do one boy's job, with the obvious results.

Recently there has been a tendency to stress the cultural side of education. I certainly agree that this is a side which has not had the encouragement or attention it deserves. In my view, however, cultural education is not a matter of teaching history or English, or indeed any so-called cultural subject. Culture surely has its roots in environment, particularly the aesthetics of environment, and in facilities for physical culture and the like. I do not believe we have in this country a single farm institute that provides the furnishing and equipment that is necessary for the fundamentals of cultural education.

Mr. Oliver Stanley, the President of the Board of Education, when opening a large technical school in Essex recently, said that the time had long since gone when in providing a college for technical instruction it was sufficient merely to provide lecture rooms and laboratories. With that now had to go all the accommodation and equipment that was required to develop physical and mental culture. Gymnasia, assembly halls, student's common rooms, swimming baths, etc., must now be provided.

So far as I am aware there is no farm institute which possesses either a gymnasium or a swimming bath, and very few have adequate assembly halls or students' common rooms.

It has been said that every county should have its own farm institute, and no doubt everyone engaged in agricultural education would welcome such a happy state of affairs. A development of that kind, however, is bound to take generations, and it would seem to me that development will have to proceed by easy stages. A new institute will probably have to be supplied in the first instance to meet the needs of a group of counties.

I suggest that when a farm institute is being contemplated for one or more counties that something more ambitious than we have yet had, something on the lines which I have just indicated, might provide the basis of a scheme.

I feel justified in going so far as to suggest that our Agricultural Colleges should first of all be extended and developed in every

direction, so as to fulfil for, at any rate the immediate future, all the farm institute requirements of the counties which they are now serving.

1. To sum up then, we ought to be and are grateful to Mr. Ramsbotham for the active interest he is taking in the development of agricultural education.

2. The Agricultural Education Association, as a whole, ought to help him as much as it possibly can to conceive a general plan and bring it into being.

3. Before any large national sum of money is made available for multiplying the number of Farm Institutes, county staffs should be brought up to full strength and adequately paid.

4. Existing Farm Institutes should be extended and improved.

5. In any new farm institute scheme, great care should be exercised to purchase a farm large enough to practise any farming enterprise on a really commercial scale.

6. Institute should provide full facilities for teaching the various sciences, and equally full facilities for recreation, physical culture, etc.

7. Finances of all Research Stations and Agricultural Colleges should be put on a more secure basis.

EDUCATION FOR RURAL LIFE: ON RAISING THE SCHOOL LEAVING AGE*

BY T. S. DYMOND

H. V. Morton, in his book *In Search of England*, describes an interview with an old craftsman in a west country village—a maker of wooden bowls. "Boys won't learn work like this now," the old man said; "it's not as easy as it looks and, unless you learn when you're a lad, you can never catch the knack of it." There are dozens of such crafts that are disappearing or have now disappeared, imported or cheap machine-made goods taking the place of the craftsmen's products, to the impovishment of village life. In my own county of Sussex, the most richly-wooded county in England, scarcely any of the one-time woodland industries remain. And this disappearance of skilled craftsmanship, in its broad sense, extends to agriculture—men skilled in arts such as hedging and thatching, in many parts are difficult to come by. It is the same in towns. In my own town, and I believe in most others, by far the largest class on the register of unemployed is the class of unskilled labourer. Work is held up for want of skilled men; it is hard to get the carpenters and bricklayers and plasterers needed to build council houses and for other public works. As the Chancellor of the Exchequer said in the House of Commons last year, the difficulty is not to find jobs for unemployed men, but to find unemployed men able to do the jobs.

The causes of this deplorable state of things are many and, in country districts, one of them undoubtedly used to be compulsory attendance at school at an age when children would otherwise have been beginning their apprenticeship, and at the time when schooling consisted of little more than bookwork. One can sympathize with the Norfolk farmer (a story told by the late Mr. Andrew Johnston, for many years chairman of the Essex County Council) who complained that his son knew nothing of nothing; he had been at school all his life! But, for the past thirty-five or forty years, the Board of Education has done much to make rural education more practical. In particular, it has issued a series of booklets on adapting education

* This paper was read at the joint meeting of the Agricultural and Education Sections of the British Association at Blackpool in September, 1936, and is reprinted here because of its special interest at the present time.

Mr. Dymond has been a member of the A.E.A. since 1898. After twelve years as Head of the Agricultural and Chemical Department, County Technical Laboratories (afterwards East Anglian Institute of Agriculture), Chelmsford, he was from 1904–21 H.M. Inspector of Schools, under the Board of Education.

to rural needs. My own *Suggestions on Rural Education*, issued in 1908, had a circulation of 8,000 copies. *The Memorandum on Rural Education*, issued in 1911, had a circulation of 7,000. *Rural Education*, issued in 1926, a circulation of 5,250. More lately, *An Experiment in Rural Re-organization* (1933) and *Education and the Countryside* (1934) have had a circulation of 3,500 and 5,000 copies respectively. (These figures are approximate.)

The principle underlying all these publications is the same, viz., making environment contribute to the fashioning of a good education. It is this and this only that differentiates rural from urban education. The last-named publication gives a remarkable picture of what has been accomplished. Not only have the geography and history, the mathematics and science been based on what comes within the children's own experience, but gardening and fruit culture, dairying and poultry-keeping, bee-keeping and fruit bottling, and numerous textile and plastic crafts have been introduced. A great deal of the work may be called vocational, but for that very reason may provide a better general education, for it cultivates the ability to acquire knowledge by experience, the kind of knowledge that counts, calls for self-reliance and initiative, and stimulates the desire to learn. As Dr. Cloudesley Brereton said at Southport last Easter, "No form of education is complete that does not possess some vocational bias."

But while there are hundreds of schools that have such a curriculum there are thousands that have not, or at any rate have nothing more than the formal woodwork and cookery that, valuable though they may be, seem to lead nowhere. For though the teaching of these subjects is not intended to be vocational, it is nevertheless surprising that while thousands more girls and boys are receiving instruction in cookery and woodwork each year, the supply seems to diminish both of cooks and carpenters. Moreover, many of the country schools are too small to undertake much in the way of rural subjects, and where they are large enough success entirely depends on the personality of a teacher. Too often, if the teacher leaves, the whole thing collapses. In fact, the adaptation of rural education to rural needs is at present haphazard in most parts of the country.

In these circumstances, can the raising of the school leaving age to fifteen be justified in rural schools?

There is much to be said of course for raising the school leaving age to fifteen (and indeed to eighteen for part-time education). Early adolescence is the age when outlook and habits are being formed for life. The teachers of senior departments want to keep their pupils till fifteen; partly because, more often than not, boys

and girls leaving at fourteen are not with them long enough to complete their three-year course. Not that that really matters if they leave school with a desire and ability to go on learning; still, as an old teacher, I entirely sympathize. In the towns the teachers want it to fill the gap between school and employment and prevent the wastage, during months of idleness, of the mental, moral and physical culture that they have taken such trouble to implant. But in the country this latter consideration rarely applies, and I do not believe that the majority of country schools as at present constituted can retain children till fifteen with educational advantage to the children. Let me give two examples.

The first is a small village school of less than forty children in the east midlands when the school leaving age was thirteen. In one little schoolroom were children of all ages from four upwards. Among them were two tall strong boys spoiling to be doing useful work on their farms, but condemned by the law to sit marking time with infants till their day of release at thirteen came. I can never forget that sad experience. My second is a quite recent case, a large village school in the south, of average efficiency. There were two boys—farmer's sons—in the top class. They were doing no good, growing more and more sullen day by day, potential criminals the neighbours feared. Then the day of their release came at fourteen and they were given work on the farm—one of them took on the milk round. At once their demeanour changed, and they became happy and useful members of society. If such a school is unfitted to keep children till fourteen, how much more so till fifteen!

Of course, the conclusion is that, while already there are isolated schools in country districts where boys and girls could advantageously remain till fifteen, before the school leaving age is generally raised to fifteen in country districts reorganization into junior and senior departments must be carried out, the senior departments being of such a size that they can be suitably equipped and staffed for boys and girls from eleven to fifteen years of age. This will involve the establishment of non-selective central schools fed by junior schools in the surrounding villages. A few counties have completed, or nearly completed, such reorganization—East Suffolk, for instance. Many have hardly begun. There are still, I suppose, some 3,000 schools with less than forty children in average attendance (3,459 in 1931).

In what way should the methods of teaching of the new senior schools be adapted to the raising of the school-leaving age? The Government are clearly expecting local authorities to tackle that question. In answer to a deputation the late Prime Minister said last year, "The education that was required from fourteen to fifteen

was not what was required from, say, twelve to fourteen and, unless preparations for the change were made, the year from fourteen to fifteen, instead of being a fruitful year for education, might be a barren one." Lord Eustace Percy had said, "The object of the extra year's schooling is to fill the gap between school and employment by directing the aptitudes of the pupils into proper channels by training them in a variety of crafts and handinesses."

You remember Edmond Holmes' *Egeria.* I knew Egeria and knew her village school. There was no gardening in a special subject sense; there was then no handicraft or cookery centre for them to attend (perhaps it would have spoilt them if there had been), yet the farmers round were eager to get the boys and girls when they left school, because they found them eager to learn, able to use their brains, and the stuff that useful men and women are made of. I found out her secret. The dramatization of history in school, in which she was a pioneer (you know her book) gave the clue. It was that every pupil as an individual member of the whole body had to depend on himself, on his own initiative, and given sufficient freedom to develop his own aptitudes. That, I believe, is the spirit that must animate the work of the extra year in the new senior schools. How can it be applied?

I suggest that, in the four-year course of the senior school, classroom teaching should be progressively replaced by individual work until in the last year the children will be able to work more or less on the Dalton plan. The staff should remember that the last thing a teacher should do is to teach. I do not mean he should never teach, far from it, but only when other methods of "learning" the children (as Sir Daniel Hall puts it) fail. The old methods of class teaching, whether in the classroom or workshop or kitchen, when every pupil is doing the same thing in much the same way, fail to develop self-reliance and adaptability, initiative and resource. In the last year the greatest possible freedom should be allowed in the choice of subjects in order that the children may find out their special aptitudes and develop them. We can envisage a school building and grounds arranged on the lines advocated in the Board's invaluable recently-issued "Suggestions," with a study-library and craft rooms as essential features, but containing subject rooms rather than classrooms, a motor-mechanics room as well as a carpenters' shop, and providing facilities not only for gardening but also for poultry-keeping, dairying, fruit bottling and such-like activities for boys and girls who have a bent for rural occupations, unless such facilities can be obtained at a farm institute or on neighbouring farms. I would emphasize a variety of crafts because I believe

that through such senior schools many of the old village industries could in time be revived, at any rate if the work were done in co-operation with the Rural Industries Bureau, whose display at the recent Royal Agricultural Show at Bristol gave such encouraging evidence of possibilities. I would almost say, *must* be revived, if rural life is to be saved from the results of excessive mechanization.

I believe that much depends on this vocational bias in the work of our new senior schools. In our desire to educate our children as good citizens we have been apt to forget that the first essential of good citizenship is ability to earn a living. I am far from depreciating the humanities as subjects of education; they are as important in rural as in urban schools. But, at present, many of our boys leave school without any vocation in view. Is it to be wondered at that too often they drift into unskilled labour to swell the ranks of the unskilled unemployed? A good example of the danger of non-vocational schooling is the "remittance men" in Canada at the end of the last century, young English public school men who were sent by their parents to Canada to make their way, but found themselves unable to put their hands to any of the occupations that offered, and were reduced to living on remittances from home. Compare this with young Meister in Goethe's immortal romance, put at a tender age along with other boys and under skilled guidance to a horse-breeding farm, there to find that, in following the vocation of his choice, every branch of knowledge was involved and every faculty brought into play. It is because Kingsley Fairbridge had something of the same vision that the Fairbridge Farm Schools provide a means of emigration that the Dominions heartily welcome.

I believe that, were senior schools established and run on the lines indicated, the claims for exemption from school attendance at fourteen that would merit consideration would be few. But the right sort of teacher may be difficult to get; there are some schools so remote that they cannot be included in any reorganization scheme; and some boys and girls who are better at a useful occupation away from school than in it. Every case must be judged by what is educationally best for the boy or girl. But I would plead that some educational influences be brought to bear on every exempted pupil, indeed as a condition of exemption, it may be through continuation classes or through winter schools for adolescents at the farm institutes (which in this way as in other ways could play an important part in reorganization schemes), or failing these through young farmers' clubs or women's institutes, or even through well-run companies of scouts and rovers or guides.

BOOKS ON AGRICULTURE FOR CHILDREN

By A. S. McWilliam

At the Annual General Meeting of the Agricultural Education Association held in Glasgow during July, 1936, a Committee was appointed to consider the existing supply of books on Agriculture for children and young persons. The Committee consisted of Professor N. M. Comber (Chairman), Professor H. A. D. Neville, H. P. Hewett (Oundle School), A. S. McWilliam (Lady Manners School, Bakewell), G. H. Purvis (Monmouthshire Agricultural Institute, Usk), J. O. Thomas (Dauntsey's School, Wilts.) and A. Voysey (Kent Agricultural Staff).

The following report was drawn up by the Agricultural Education Association Committee and presented on 12th November, 1936, to the Joint Committee of the Ministry of Agriculture and Board of Education which solicited the Association's views in the first case.

Report of the Committee

General

The majority of the books concerned with agriculture are, so far as the Committee could determine, mainly of two kinds:—

(1) Very elementary books suitable as nature study readers for junior children (8 to 10 years of age).

(2) Advanced or technical books which can only be used satisfactorily when a course in general science up to the school certificate standard has been taken.

The intermediate books are very inadequate. While some of them are good in parts, none is really suitable, and animal husbandry is either omitted or indifferently dealt with.

Some members of the Committee who teach agriculture in schools had not found the need for agricultural text-books for use by the scholars; they would, however, welcome a suitable and reliable text-book on agriculture written with a sound practical bias.

The Committee was very decided on the point that teachers must have some acquaintance with practical agriculture if they are to make a success of the work. For teachers without such knowledge, courses should be arranged on the farms of agricultural colleges or University Departments of Agriculture.

The use of films in teaching was mentioned as a good way of presenting practical farming and the scientific operations involved in many of the agricultural industries.

Practical work on the land by scholars is considered to be a useful accompaniment of reading where facilities are available, and the results of experiments, statistically treated, provide useful

material for study. Such work, however, is not by any means essential, particularly if the scholars can visit farms and gardens from time to time and see something of the practical work.

TYPES OF BOOKS NEEDED.

The Committee considered that three types of books are desirable:

(1) A book on the elements of agriculture, including animal husbandry.
(2) Booklets dealing with various branches of husbandry.
(3) A general reader on farming suitable for young persons who have no knowledge of agriculture.

1. *Books on the Elements of Agriculture.*—It was felt that the supply of books for children who have passed the school certificate examination raised no serious difficulty. A number of books were examined by members of the Committee, but it was impossible to find among them a suitable *comprehensive* book for children in the senior rural schools and in rural secondary schools between the ages of 12 and 16. Some books which are or have been used in schools are set out in the appendix.

The "ideal" book should conform to the following points:—(*a*) It must be well written in a clear, attractive and simple style with a strong practical bias. (*b*) Technical terms, except those in common use, should be avoided as far as possible. The terms used must be explained. (*c*) The book, although simply written, must not be an elementary one. The Committee consider that fairly advanced knowledge can be taught to children if appropriate language is used. (*d*) It must contain descriptions of experiments, set apart from the text, which can be performed by the children in the school laboratory and in the school garden or on the farm. (*e*) Each chapter should contain application questions and suggestions for further study. (*f*) The descriptive matter should not consist of hints and tips but should be a reasoned account stressing the principles and the reasons why things are done. (*g*) It must be well illustrated by diagrams, drawings and photographs. (*h*) The cost should be low—3s. 6d. to 4s. (*i*) The subject-matter should embrace:—Soils and soil micro-organisms. Manures and manuring. Seeds, crops and rotations. Elementary plant and animal physiology, with reference to plant nutrition and the digestion of foods by animals. Animal husbandry —chiefly as regards the principles of nutrition, feeding and management of farm stock. Milk production. Reproduction in plants and animals. Heredity.

The Committee suggest that a book on the lines of *Elementary Agricultural Science* by Wm. Smith, with certain modifications, omissions and additions would meet the need.

2. *Booklets dealing with Various Branches of Husbandry.*—These books should be written from the standpoint of the husbandman and would be valuable to those who have covered the ground of a book on the elements of agriculture in pursuing the further study of special subjects. The books should be small and inexpensive, not costing more than one shilling, and should be bound in reasonably stiff covers. They should meet the needs of young farmers' clubs as well as school classes.

Those books dealing with farm live stock should contain:—(1) A drawing or photograph of the animal, naming all the points so as to make the terms intelligent to the reader. (2) The good points of the animal, illustrated by photographs on the lines of the "Stock-judging illustrations" published some years ago by the *Agricultural Gazette*. The reasons why these points are important should be stated. (3) The description of only a limited number (3 or 4) of breeds. (4) An account of feeding, breeding and management. The various systems of management should be briefly explained.

The following is a suggested list of subjects for such booklets:—

(1) Care of Live Stock. (2) Principles of Feeding Farm Stock—Rations. (3) Pig Keeping. (4) Cattle and Calf Rearing. (5) Horses: Their breeding and management (farm work horses only). (6) Sheep: Breeding and Management. (7) Heredity and breeding of Plants and Animals. (8) Animals in Health and Disease. (9) Milk. Its production and products (butter and cheese). (10) Poultry: Breeds and Management. (11) Rabbits: Breeds and Management. (12) Goats: Breeds and Management. (13) Beneficial Insects. (14) Bee Keeping. (15) Cultivation of the Soil. (16) Manures and Manuring. (17) Farm Implements (or Farm Engineering). (18) Grassland and its Management. (19) Fruit Growing. (20) Insect and Fungus Pests of Farm Crops and Stock. (21) Identification of Grasses. (22) Common Weeds and their Eradication. (23) Farm Records for Poultry, Pigs, Milk Production, etc. (24) Farm Calculations or Arithmetic, with examples. (25) Farm Experiments and Research. (26) Agricultural History and Law. (27) Farm Management and Capital.

The Committee suggest that Nos. 1 and 2 should be studied before any of the booklets on Farm Stock, and that Nos. 15, 16 and 17 should be read before Nos. 19 and 20. The order for study should be stated inside the cover of the booklet.

3. *A General Reader.*—A comprehensive book on farming for the use of young people who have no knowledge of farming is considered to be urgently needed. The book should be written to

create an understanding of farm life as well as of the industrial operations of farming and language and terms which are well understood in the farming community but not in the town should be carefully explained.

Appendix

Some books which have been found useful as readers or for teaching special subjects.

(*a*) Ages 8 to 11:

1. *The Farm Shown to the Children* (Blaikie & Meadow). T. C. and E. C. Jack, 3s. 6d.
2. *On the Farm* (Cameron)—Photographs. Rambler Nature Books Series, Blackie & Son, 1s.
3. *My Little Farm Friends* (Causland). Out of print.
4. *Lessons on Soil* (Russell). Camb. Nature Study Series, Camb. Univ. Press, 3s.
5. *The Young Rider's Picture Book* ("Golden Gorse") (and for older children). Country Life, Ltd., 7s. 6d.

(*b*) Ages 12 to 16:

6. *Fertility of the Soil* (Russell). Camb. Nature Study Series, Camb. Univ. Press, 3s.
7. *Weeds* (Lloyd Praeger). Camb. Nature Study Series, Camb. Univ. Press, 1913, 3s
8. *A Farmer's Handbook* (Andrew) Revision desirable. Bell & Son, 1920, 6s.
9. *Elements of Agriculture* (Fream). First Edition. Murray, 5s.
10. *Introduction to Forestry for Young People* (Agnew). 1s. 3d.
11. *A Short History of Agriculture* (John Orr). Camb. Univ. Press, 1922, 2s. 6d.
12. *Tillers of the Soil* (Newbigin). Macmillan, 1s. 6d. to 2s. 6d.
13. *Outlines of Fungi* (Bennett). Macmillan, 1924, 7s. 6d.
14. *Genetics* (Sinnott & Dunn). McGraw Hill, 17s 6d.
15. *Chemistry for Rural Schools* (Jones & Griffiths). Blackie & Son.
16. *Plant Growth in the Soil in Relation to Foodstuffs* (Pingriff). (Practical experiments). A. & C. Black, 1s. 6d.
17. *Surveying for Agricultural Students* (Haines). Longmans, Green & Co., 1929, 12s. 6d.
18. *Science in the County* (Little). Pitman, 2s. 6d.
19. *First Book of Rural Science* (Green). Macmillan, 2s. 6d.
20. *Rural Science* (Mason & Dow). All experiments. McDougall's Educational Co., 2s.
21. *The Story of a Loaf of Bread* (Wood). Camb. Univ. Press, 3s.
22. *The Complete Farmer* (McConnell). Cassell, 1910. Out of print.
23. *An Introduction to Science.* Book IV, "Earth and Man." (Andrade and Huxley). Basil Blackwell, Oxford, 3s. (Practical Work), 6d.
24. *Elementary Agricultural Science* (Wm. Smith). Oliver & Boyd, 1923, 3s.
25. Some Bulletins published by the Ministry of Agriculture.
26. *Poultry Keeping for the Small Poultry Keeper and the General Farmer* (Flatt). Methuen, 2s. 6d.
27. Novels on farming (A. G. Street).
28. *A Honey-Bee and Her Master* (D'Arcy Chapman). Blackwell, 7s. 6d.

A NATIONAL POLICY FOR AGRICULTURE*

By C. S. Orwin

Director of the Agricultural Economics Research Institute, Oxford

It is a long time since this country had any positive policy for its agriculture. The repeal of the Corn Laws marked the end of the supremacy of the landed interest in national affairs, and the final recognition of the predominant importance of the industrial worker. From that time onward for nearly ninety years, farming in this country was left to stand or fall, to develop or to recede, as open competition might determine. There was no longer felt to be any particular virtue in maintaining the English countryside, and farming had to fall into its place as one of the many industries of the country.

Everybody knows what were the consequences. For the next thirty years the rapid growth of the industrial population by contrast with the very gradual increase in food imports combined to maintain agricultural prosperity, and it was not until the end of the 'seventies that the effects of the policy of free trade began to be felt. First, the development of transport and the invention of harvesting machinery opened the British market to the prairie corn-grower, and drove the English farmer more and more to live-stock. Then, the invention of refrigeration brought an attack upon the meat industry, though for a long time in this market he enjoyed a natural protection due to the superior quality of his product. But he turned more and more to dairying, as almost his last unassailed stronghold, until this too began to fail him in the post-war years, as the butter makers and cheesemakers of the Antipodes and elsewhere saw their opportunity.

By 1930, therefore, eighty-four years after the repeal of the Corn Laws, the British farmer was experiencing the full effects, in all the main branches of his business, of a national policy of free trade in food. To aggravate this, the economic crisis supervened.

It was then that the reversal of this policy was resolved upon. The National Government decided that agriculture must once more be protected. Now this sounds a fairly simple thing to do. It is true that there are various ways of doing it. You can impose straight tariffs on all imports; you can restrict the volume of imports; you can subsidize the home-producer or the home-consumer; you

* Paper read at the December meeting, 1936.

may even restrict home-production. Which of these methods is the best in any set of circumstances is a matter for discussion, but one way or another there is no difficulty about formulating a protection policy.

But is this enough? Have you achieved your purpose, which is to increase production from the land by making farming prosper, by resorting to one or more of these protective measures? In a country where the majority of farmers are occupying-owners, and the majority of them of the peasant class, the answer might be "Yes." But will you have succeeded in your purpose in a country such as Britain, where most of the land is in tenant occupation and most of the tenants are employers of wage labour? I suggest that the answer is "No." In spite of the break-up of estates, more than two-thirds of the land of this country is occupied by tenant farmers, and wages for farm labour are fixed by a wages board. It follows inevitably that any rise in farming prosperity is going to increase the competition for farms, so that rents will rise, and further, that wage labour will maintain its claim to share in the new prosperity and wages will rise. There may be a lag between the rise in prices and the rise in rents and wages, but it is only a question of time before most of the benefits of a policy of protection will have passed from the farmer to his landlord and to his workers.

This brings me, then, to my first observation upon the formulation of a national agricultural policy for this country. If the nation is prepared to use measures to produce an artificial prosperity, it is committed to the nationalization of the land as a preliminary step. At worst, the results of its protectionist policy then will be to give back to the State, in the form of higher rents for its land, the price which the community has paid to protect its farmers. At best, the State might use the competition for farms to secure better farming rather than higher rents.

But if the State had taken this preliminary step, and it had become the universal landlord, it would not follow that national policy could be satisfactorily carried out by the policy of general protection. There is a limit to what we can afford to pay for, and it is suggested that we ought to select from among the many branches of farming those that are most essential to us, and make them the objects of our help. Unfortunately, the authorities, to use a convenient term, have never settled down to consider which these are; there are at least four conflicting lines of policy which are being pressed upon the country at the present moment. They are all of them mutually exclusive, and it should clear the air to state them and to grasp their implications.

Nutrition.—First of all, there is the policy of which so much has been heard during the last year or so, namely that which would concentrate State aid on the production of the so-called health foods. The nutrition experts tell us that protection from disease is best achieved by a more varied dietary which includes fresh foods of all kinds, fruit, vegetables, eggs and dairy produce, in greater quantity. All of you must have seen the reports recently issued, showing the low standard of nutrition of great masses of the people, when measured by the standards laid down by dieticians. They question the wisdom of subsidizing the production of wheat and sugar, which are foods with a low vitamin content, obtainable in great quantities at low world prices and easily transported. They suggest that it would be sounder for the State to spend the money on making milk, eggs, vegetables, etc. available in much greater quantities, at prices within reach of the thousands who to-day cannot afford to buy enough to save themselves from malnutrition.

As a policy it seems good. Let us exploit the sweated overseas producer of cheap corn, cheap sugar and cheap meat, and help our consumers to get the perishable home-grown foods in great quantity. The method, doubtless, would be by subsidizing the consumer, as is done already by the milk-in-the-schools scheme, so as to lower prices to certain categories of the population. As a practice, none of its advocates have applied themselves to the question of re-planning much of the agriculture of the country, which would be necessary if it were adopted.

Defence.—Then there is the policy which has been brought very prominently to our notice in the last few days, by Mr. H. L. French's new appointment. This policy aims at organizing agriculture as an instrument of national defence. It is deplorable to think that this peaceful art should be debased by measures which associate it with munitions of war, but the fact is that while we could not feed the people of this country indefinitely on home-grown produce, it might be possible by the deliberate encouragement of certain types of farming, and by storage and other measures, to survive a considerable period of blockade. The advocates of this policy have no quarrel, in theory, with the advocates of health foods, indeed, they would support them in abstract, as tending to produce a more virile nation fit to endure the strain of modern warfare. In practice, however, they suggest that the primary food products must take first place, on the grounds that in a national emergency people will be well content to forgo tomatoes, eggs and small fruit if they can be assured of beef, bread and sugar.

Everyone can imagine for himself how the production side of the policy of national defence would be organised. There would have to a putting-back of the clock, a return to the 'sixties of the last century, when corn and meat were of principal importance, with the addition of only just enough of the dairying industry to keep the country in fresh milk. The wisdom of the policy is a question of the individual's assessment of the chances of war.

Land Settlement.—Third, there is the policy of putting more people on the land, both as an end in itself and as a contribution to the unemployment problem. I can only say with great respect that I regard this as the most unsound of all the policies proposed. The subsidy required to settle men on the land in small holdings is the most expensive form of agricultural protection, if it is farm workers you want to settle, or of unemployment relief if it is Durham or South Wales miners. The forty millions spent on sugar beet has at least increased the output of the plough lands of East Anglia, but every additional family settled on the land reduces the surplus produce available for sale to industrial consumers. Production of food over and above the requirements of the producer varies inversely with the size of the holding, and the smaller the farm the larger the proportion of its output which is consumed by the farmer and his family. The land settlement policy is based upon the sentimental appeal of the small man and analogies with Continental countries having a peasantry apparently prosperous and contented, which ignores the fact of their low standard of life and want of any alternative occupation. Whether the aim of the country be to produce health foods or the prime necessaries of life, a small-holdings policy can only result in a smaller home-grown food supply for the consuming public.

The Status Quo.—Lastly, there is a fourth policy to be considered, the policy of preserving the present organization of farming, without any attempt to utilize State aid to direct it into any new channels. The argument for this policy is that the farmer knows his own business best and that any interference with the lines of production which he is pursuing is undesirable. It suggests that farming has evolved as far as it is likely to go and that all that is needed of a State policy is to stabilize it at this point by making every branch of it equally profitable. The dairy farmer will then be relieved of the competition of the beef producer who has turned over to milk in despair of making beef pay, and the barley grower in the eastern counties and the oat grower in Scotland will cease to cast envious eyes on the wheat grower. "Leave us all alone," say the advocates of this policy, "to farm as we like without

interference from Whitehall, but guarantee us a profit for anything we like to produce."

The danger of such a policy is that it does nothing to stimulate efficiency. The standards of the mediocre farmers determine the amount of protection to be given, and the incentive to cut costs and to experiment in new methods declines as the certainty of profits increases.

It is this policy so far which most nearly describes that which the State has adopted. There has been no attempt to consider how much farming the country can afford to subsidize; no attempt so far to consider whether national health or national defence or unemployment relief should be the purpose of the subsidy. Instead of a policy of selective protection, wheat, beet sugar, fruit, vegetables, hops, potatoes, meat, eggs and dairy produce, have been protected by one means or another. And already the results are being passed on by the farmer to the farm worker through a general rise in agricultural wages, and to the landlord by a rise in rent on any change of tenancy.

The nationalisation of the land is not yet a matter of practical politics, but there are signs that the large-scale experiments in organization and in assistance, upon which the Government has been engaged during the past five years may lead to something more definite in the near future, designed to reconcile the claims of nutrition and national defence so far as possible. Land settlement is likely to receive no more than lip service, and the farmer who wants no interference from Whitehall cannot ask that Whitehall will fill his pockets. Everyone will agree that something had to be done if the country were not to have lost much of its rural life and industry. What the policy for their retention and development should be is a matter, I suggest, which calls for far more consideration than has been given to it as yet.

A SURVEY OF PIG RECORDING*

By J. W. Reid

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Pig recording, in one form or another, has been an integral part of production in some foreign countries for a number of years. Various systems including pig recording, litter testing, advance registers, and élite classes are in operation.

In 1907, Denmark introduced a scheme, and since then schemes have been developed, usually on a national basis, in the following countries:—Austria, Canada, Czechoslovakia, Denmark, Estonia, Finland, Germany, Latvia, New Zealand, Poland, Holland, Sweden, United States of America, and U.S.S.R.; while in France a scheme is under consideration. In some countries, performance records are obligatory on all pedigree breeders; in others, they are voluntary.

PRESENT METHODS IN GREAT BRITAIN.

In this country the initiative in pig recording was taken by the Agricultural Department of Cambridge University, when, in 1927 with the co-operation of the Empire Marketing Board and the Ministry of Agriculture, the East Anglian Pig-recording Scheme was inaugurated with the object of demonstrating the possibilities of recording. This scheme operated for about three years, and as its details are familiar to most people engaged in agricultural education there is no need to elaborate them here.

In 1928, a pig-testing station was established by the Animal Breeding Research Department of the University of Edinburgh, in conjunction with the Board of Agriculture for Scotland, but this station is now defunct.

In the same year the National Pig Breeders' Association commenced recording in their herd book the number of pigs born and weaned in each litter, and this led to the preparation of an Advanced Registry for sows.

From May, 1928 to May, 1931, the Pig Industry Council constituted by the Minister of Agriculture was in being, and in May, 1931, issued a report dealing with Litter-testing Stations, Pig Breeding, and Advanced Registers. Earlier, in February, 1930, the Council had stated that "the supreme importance of pedigree of performance is insufficiently understood in this country." Nevertheless when their report on this matter was issued, the Minister of Agriculture, while acknowledging the subject as of "fundamental importance to the pig industry," stated that owing to the suggestions "involving expenditure on a new service for which money is not

* Paper read at the December meeting, 1936.

available at the present time . . . the question of giving effect to the Council's recommendations must be deferred."

In 1933, the Re-organization Commission for Pigs and Pig Products presented their report, one of the features of which was the section devoted to measures for the improvement of home production. The Commission recommended a Pig Industry Development Board whose duties would include the organization of efficiency measures, and special mention was made of pig recording.

In 1931, a pig-recording scheme on a county basis was commenced in Wiltshire. This was modelled on the East Anglian scheme.

In 1933, county schemes were inaugurated in Hertfordshire and Bedfordshire, Kent, Hampshire, the Isle of Wight, and Essex, in that order, and more recently a few other counties have taken up similar work. In 1933, the Central Council of Milk Recording Societies prepared a scheme for the guidance of their constituent societies in commencing pig recording, and in 1936 the Bath and West Society sponsored a scheme.

THE FUTURE DEVELOPMENT OF PIG RECORDING.

It must be admitted that the schemes in operation to-day have failed to really interest any significant number of breeders or farmers. This is probably due to the active criticism of many, to the trouble and expense involved, to fears of publicity, to fears of disease, to a misconception of the function of records, to the lack of an incentive to produce recorded stock, to the lack of uniformity in the methods practised, to fears that recording may destroy type and/or constitution; but, in the writer's opinion, it is mainly due to the fact that the service hitherto offered is inadequate and has failed to differentiate between the especial needs of the breeder of pedigree pigs and the breeder and feeder of pigs for the commercial market.

As a result of experience with pig recording through the Hertfordshire Pig Industry Association, with the pedigree herds at the Institute, by studying methods in other countries, through visits to Sweden and Germany and through talks with personal friends, I am convinced that the first step in the future development of pig recording is to get right away from the words "record" and "recording." The term "record" is so often associated with some spectacular result, and is so often misued, that pig breeders have come to regard pig recording as the securing of exceptionally high weights at weaning or whenever they are weighed; and there is no doubt that not only is this conception general, but that it is one of the major factors retarding the development of the movement.

The object of an intelligence service to breeders and feeders is

presumably to effect and maintain a high standard of quality in the animal produced, to ensure a satisfactory standard of production, and to afford a means of checking and improving management. To accomplish this it will be necessary to divide any scheme into two parts, and experience indicates that this is not only essential but undoubtedly sound.

On the one hand there is the pedigree breeder whose first aim is, or ought to be, the maintenance and improvement of breed standards, i.e. the type and character of the breed, its fecundity and rearing ability, its capability of economic early maturity, and its fitness to satisfy market requirements. To a certain extent it is immaterial at what cost this is achieved; cost of production may not be the first consideration.

On the other hand there is the commercial pig breeder and feeder whose main object is to produce high quality pork or bacon at an economic cost of production. He should be able to rely on the pedigree breeder to supply him with breeding stock of good quality and of proved performance, but must have some means of checking and controlling his management.

I am certain that this conception is fundamental; each part is complementary to the other, though if desired, a pedigree breeder could also take advantage of the management control scheme.

A Scheme for Pedigree Breeders.

To deal first with the outline of a scheme suitable for the pedigree breeder, it is submitted that he requires the fullest possible information. To quote Buchanan Smith, "A pig with a pedigree implies that it is aiming at something higher than the average. A pig with a statement of performance provides information as to whether it has or has not achieved this."

The suggestion here is to establish a Pig Performance Register. This register should be independent of all breed societies, but supported by all. It should be controlled by a committee representative of breed societies and of county or area pig industry associations. Alternatively it could be controlled by the breed societies were they welded in one national association. In it would be noted the performance of animals vouched for by the county or area pig associations, which would in turn be responsible for the field work necessary for its compilation. Again, were the Register in the hands of one national association of all breeds, the performances would be vouched for by the area officers of that association.

No figures should be given under individual animals but the animals could be classified according to their performance. For

example, sows which had reared a given number of pigs in a given number of litters would appear in one section. Sows which had weaned pigs to a minimum weight might appear in another section. A third section might be devoted to sows whose progeny had achieved a minimum standard of age for weight, while a fourth might include those sows whose progeny achieved a minimum standard of carcass quality. The animals in each section of the Register might later be grouped into a superior sub-section and a standard sub-section, if it were considered desirable to do so. In this way there would be no incentive to secure spectacular results, each animal would be approved as it were, for performances which could be definitely measured, and for separate performances. A sow, for example, might appear in the sections for number weaned and for weight at weaning and not in the other sections, another sow might appear in three sections, and others might be in all sections. The intelligent interpretation and use of such a Register would have a marked effect on breed improvement.

In order that breed type may be maintained it would be essential that animals should be subjected to type inspection prior to entry in the Register. I should regard this type inspection as vital to the full success of the scheme.

The field work involved in the compilation of the Register would include noting the number of pigs born and weaned per litter, the weight of these pigs at agreed ages, and where practicable, information on carcass quality.

With regard to the ages at which the pigs are weighed, my own view is that they should be weighed at three weeks and 8 weeks' old, that is while on the sow and at weaning, and that an additional weighing should be made at some stage between weaning and maturity. All pigs in the Institute herd are now weighed every fourteen days, but such regular weighing, however desirable it may be, could not be done on every farm. On the other hand, there should be no insurmountable difficulty in securing one weighing; and twenty weeks old is suggested as a suitable age for this purpose. This would give an age-for-weight figure, and would thus be a measure of capacity for growth. It would to a certain extent give an indication of the health and subsequent history of the litters, and would normally bring in most pigs before they were sold.

To deal with carcass quality, there can be no doubt that testing stations would be invaluable, and they of course would enable food consumption figures to be accurately determined. Alternatively, arrangements might be made to provide facilities at selected factories where carcasses could be measured to some definite points, e.g.

length of side, rib number, length of loin, thickness of back fat and streak, length of leg, etc. Any carcass examination should be restricted to definite measurements, thus eliminating estimations completely. The practical application of this aspect of the scheme could be dealt with by arranging for the area official to be in attendance at the specified factory on a given day each week.

A scheme on these lines offers very full information to the pedigree breeder, and information which could be invaluable to him in his work. It leaves out of account food consumption unless testing stations are introduced but, as already indicated, the main concern of the pedigree breeder is the maintenance and improvement of breed standards in their fullest sense. If this conception is approved, the question of food consumption is relatively of minor importance.

A Scheme for Commercial Farmers.

It has already been stated that the main object of the commercial pig breeder and feeder is to produce high quality pork or bacon at an economic cost of production, and that his main need is to have some means of checking and controlling his management.

To provide such means it is suggested that the most satisfactory procedure would be to establish Pig Production Surveys. Such surveys could be undertaken by county agricultural education staffs, or alternatively by area pig industry associations such as envisaged as being responsible for the field work involved in preparing the Pig Performance Register. In any event the agricultural education staffs should be closely associated with such work.

The basis of the Production Survey should be a monthly diary, which could be a form with a space for each day of the month. On it would be entered the number of sows farrowed; birth to weaning data incorporating the number of pigs born; the number of pigs died and the number of pigs weaned; the number, kind, weight, grade (in the case of baconers) and price of all pigs sold; the deaths of pigs and the cause, if known; and the number, kind, and price of pigs purchased.

In this case there would be no weighing of the pigs at weaning, but the data obtained would provide very valuable information, which on being analysed, would provide individual and comparative standards of production, and thus enable a farmer to detect weak spots in his management.

Such a scheme would be comparatively simple to operate. The forms could be bound in books so that one copy could be kept on the farm and the other collected on a monthly visit by a member of the staff concerned, or posted direct to the office involved. Where the

forms were posted it would be advantageous for periodic visits to be paid to the farms. The keeping of the necessary data should be well within the ability of any intelligent farm worker. Once a month the forms could be tabulated, and quarterly and annual summaries prepared for the information of the co-operating farmers.

Information on carcass quality, which would not require to be so detailed as in the case of pedigree herds, would be obtained from the grading returns for bacon pigs.

So far no suggestions have been made regarding the incorporation of a food control scheme in the Production Survey. There is no doubt that the addition of such a scheme would greatly enhance the value of the survey, *so long as the information was accurate or even reasonably accurate.* Personal experience in checking food consumption on the farm indicates that any food control scheme bristles with difficulties; but difficulties are only there to be overcome.

The first essential is to determine some means of separating the food consumed by the pigs from that consumed by all other livestock. This need not be actual physical separation although that would be preferable. It could be done through a system of weekly or fortnightly indents.

The success of the scheme would depend, on the efficient working of an indent system. The pigman would prepare a sheet showing the quantity of food to be fed to each pen at each meal and from this it would be comparatively simple to prepare the weekly indent sheet.

The second essential would be to classify the pigs into groups such as breeding stock, including sows, suckling, empty and in-pig, in-pig gilts, boars and suckers; and fattening stock including all pigs over eight weeks old. In self-contained herds it would also be necessary to keep a note of the transfers from fattening pigs to gilts for example.

On this basis the weekly indent would show the quantity of each kind of food issued to each class of stock. These indents could be combined into a monthly return and dealt with in the same way as the stock return. If the monthly return could be supported by a food agreement showing the foods in stock at the beginning and purchased during the month, with the foods issued during the month and in stock at the end of the month, it would be a desirable check.

A food control scheme of this nature would give the farmer a check on the actual quantities of food fed. It could be utilised to give the quantity of food fed to breeding stock expressed as the food requirement per pig weaned, and if the weight of all pigs leaving the farm could be incorporated in the stock return, it could, by assuming a weaning weight, give a figure for the food conversion by fattening pigs.

It must be realized, however, that the addition of a food control scheme might be considered by a numbers of farmers as involving too much clerical work. At the outset it might be made an optional part of the Production Survey, although such a survey cannot be regarded as complete until it does include such a scheme.

CONCLUSION.

A pig production intelligence service is essential to the industry as a whole. It is essential to the pedigree breeder because it will give him more detailed information on which to build his breeding policy; it is essential to the commercial farmer because unless he is able to detect weaknesses he can never improve his methods; it is essential to the meat industry because better quality stock and better managed stock means high quality pork and bacon; and it is essential nationally if we are to maintain our reputation among the countries of the world as the finest stockbreeders in the world. But if the principle of a pig production intelligence service is admitted, let it be a service which is uniform in its methods throughout the country. This vital principle must be accepted.

To achieve this it is essential that a national lead should be given. Hitherto authority, whether represented by the Ministry of Agriculture, or the Marketing Boards, has been unable to render much help. Many had hoped that the Pig Industry Development Board envisaged by the Re-organization Commission would be the responsible authority, but that Board has been constituted as the Bacon Development Board, and it would appear that its main work may lie on the bacon side. It is necessary to remember also that any pig production intelligence service must be available equally to pork and bacon pig producers, and the constitution of the Board may be too narrow to permit this.

Nor should it be the function of local or semi-national bodies to frame national schemes. In the absence of a Pig Production Board, or failing the resurrection of the Pig Industry Council, the proper authority would appear to be the Ministry of Agriculture or the Agricultural Research Council.

As a first step the standards which might be worked to should be examined and codified. This could best be done by a committee representative of scientific, breed society, and educational interests working under the ægis of the Ministry of Agriculture or the Agricultural Research Council. Such a committee might well be charged with the organization and conduct of a pig production intelligence service on a national basis.

THE ART AND SCIENCE OF PLANT BREEDING*

By G. D. H. Bell

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Plant breeding, in the widest sense of the term, embraces all those means by which conscious improvement of plants may be accomplished, and includes the introduction of new forms, the selection from mixed populations and hybridization. Methods of breeding have been influenced very strongly by recent advances in biological science, and it is becoming customary to speak of scientific plant breeding, as if drawing a distinction between the art that was practised by the older breeders and the science which has developed during the twentieth century. The increased and more enlightened use of hybridization as a means of plant improvement is, of course, mainly a direct result of the growth of the two sciences of genetics and cytology, and it is interesting to try and assess the true value of the application of genetic and cytological principles to plant-breeding problems.

It should be realized that the problems which confront the breeder are dependent on the particular crop with which he is dealing, and the agricultural and environmental considerations which determine the refinement of the methods he is justified in employing. It is therefore impossible to deal adequately with all aspects of breeding procedure and technique in a short article of this nature, but certain general principles may be stated which are common to all circumstances.

If the improvement of cereal varieties in this country be taken as an example of the art of plant breeding which was practised before the scientific era, it will be seen that great advances were made by men who practised selection. This selection work was either systematic within the mixed populations which were grown as agricultural varieties at that time, or else it was of a purely chance or haphazard nature.

Such well-known and valuable varieties of cereals as Potato and Sandy oats, Chevallier and Goldthorpe barley, and Squarehead wheat were the result of chance selection by men who knew little or nothing of plant-breeding methods. On the other hand, William Le Couteur and Patrick Shirreff evolved methods of systematic plant selection

* Summary of a paper read at the December meeting, 1936.

by which they exercised their natural gifts for recognizing superior plants. Shirreff was very successful in his work and made available to the farmer such varieties as the Fellow oats and Hopetown oat, and Red Bearded and White Bearded wheats.

The improvement of cereals by this means is, of course, dependent on the mixed nature of the varieties cultivated, and there is not the scope for such work to-day when purity of seed has been stressed so incessantly by all who handle cereal varieties.

But hybridization was also practised by the earlier breeders before scientific genetics had been evolved. Thomas Andrew Knight and Shirreff were among the pioneer cereal hybridists of the pre-Mendelian era in this country. Very little in the form of improved agricultural varieties resulted from their work because they did not appreciate the phenomena of inheritance which are known to-day. Hybridization between varieties possessing the desirable characters which were required in one individual was recognized by Shirreff as being the quickest method of producing improved forms, and he realized the importance of isolating pure lines from the hybrid material. But in addition to simple intervarietal crosses, the possibilities of inter-specific crosses, back crosses and compound crosses, were being investigated on the Continent. Henri de Vilmorin, for example, studied inter-specific crosses in wheat for the purpose of creating a greater diversity of types for breeding purposes.

It is interesting, therefore, to realize that the standard methods of plant improvement were recognized and practised before the scientific era which was to a large extent ushered in at the beginning of the present century. Selection without hybridization was the method which was largely responsible for improvements. Hybridization was successful in the hands of certain breeders, such as William Farrer, John Garton and Luther Burbank, who all succeeded in producing improved forms without the application of genetic principles as recognized to-day. Luther Burbank, in fact, worked in pre-Mendelian and post-Mendelian times, but he refused to accept the findings of Mendelian experimentation, and denied that Mendelian inheritance was in any way adequate when applied to practical breeding. Burbank succeeded in producing more new and improved forms of cultivated plants than any other man before or since his time, and he may be taken as the classical example of the exponent of the art of plant breeding.

The Influence of Modern Genetics.

The ultimate factorial analysis of plants from the point of view of their hereditary complements has never proved the feasible

proposition which the earlier Mendelian work promised. This work, which to a large extent supported Mendel's original hypotheses, was based on the inheritance of comparatively simple morphological characters and led to the conception of "Mendelian characters" and "unit factors." The original hypotheses have been enlarged and modified as evidence has accumulated, but as yet no satisfactory explanation has been given for the inheritance of many of the more important physiological characters which are so important in plant breeding.

It is often contended that genetic science has revolutionized practical breeding by explaining the phenomena of inheritance, and thus enabling the breeder to work in an enlightened manner where the pre-Mendelian breeder groped in the dark. There is much truth in this contention, but it has been over-emphasized. The stimulus of Mendel's work has been responsible for a vast amount of genetic analysis, which has made it possible to enunciate certain basic rules for plant-breeding procedure. These rules ensure that elementary mistakes are avoided, and it is possible to plan hybridization experiments more intelligently and with a greater saving of time, space and energy. In addition, genetic research has supplied an explanation for various phenomena of inheritance which lead to certain complicated forms of inheritance. But perhaps one of the most important contributions of genetics has been in connection with the philosophy it has engendered in the mind of the breeder, and the greater confidence with which he approaches his problems.

It may be said, therefore, that genetic science has contributed in many ways towards more enlightened work in plant breeding, and the direct application of genetic principles has been instrumental in solving some problems in the production of new and improved varieties of plants by hybridization. But there have been definite limitations to this application of genetic principles, because some of the most important questions which have confronted the breeder have resisted all attempts to analyse them genetically.

The characters with which the plant breeder usually works, and in which he is particularly interested, are for the most part complex physiological characters, or what may be called "character complexes." They may be the visible or measurable results of several simpler characters, or else they may be end-products of physiological processes or developmental phenomena in the plant about which little is known.

Such characters as yield, winter-hardiness, earliness, resistance to lodging, and all that is implied in the general term "quality,"

may be taken as examples of these character complexes, the inheritance of which may not only vary with the particular crop under consideration, but also with different varietal crosses within any crop. In some cases the method of inheritance is not known, while in other cases something is known but little is understood of the phenomena, a fact which makes it impossible to predict what forms will segregate or to calculate mathematical ratios.

This does not necessarily mean that new phenomena of inheritance are under consideration, because it can scarcely be expected that these character complexes should behave in the same manner as the unit characters of Mendelism. It is true that new conceptions of multiple factors, quantitative inheritance, transgressive segregation, and factor combination and inhibition have been invoked, but these have helped but little.

Even if genetic analysis were possible, recognition of genotypes is often so difficult that it is impossible to separate them from environmental fluctuation. Eye judgment is in many cases quite inadequate, and simple empirical tests are not always available for isolating all the genetic variants. It seems probable that genetic analysis of these characters cannot reasonably be expected, but each complex must first be analysed into its component parts.

Yield in wheat, for example, is dependent on the number of ears per plant, the number of spikelets per ear, the number of grain per spikelet, and the thousand grain weight, not to mention the ancillary characters of a strong straw and a well-developed root system. Simple genetic segregation can scarcely result in hybridization involving so many characters, unless groups of characters are inherited as one character. It is true that linkage does occur between certain characters, so that simplification may result in the genotypic variation.

There are some investigators who believe that Mendelism has but a limited application to the hereditary phenomena in plants and animals, and who think that the gene concept, which is the basis of modern genetic interpretation, does not apply to the inheritance of physiological characters. This argument cannot be entered into here, but there certainly seems little justification for making a universal law out of an hypothesis which has been shown as yet to apply only within certain limits.

Because of this failure to elucidate those very problems with which the plant breeder is directly concerned, plant breeding still remains to a large extent an art which is dependent on the judgment and experience of the breeder. There is a tendency among some breeders to turn away from genetic science, at least temporarily,

and to study plant development and behaviour more thoroughly. From the plant-breeding point of view one of the most urgent needs is the analysis of the character complexes, and a closer study of individual and varietal behaviour in relation to these characters and the environment. When this has been accomplished, there may be a greater application for genetics in plant breeding.

The Significance of Cytological Investigations.

The study of chromosome behaviour, structure and number, which embraces in general terms the science of cytology, has developed with the later stages of genetic investigation. In addition to supplying the mechanism of hereditary behaviour it has also explained many peculiarities of hereditary phenomena, particularly in relation to crosses between distantly related parents. Cytology has therefore proved of more direct value to the geneticist than the plant breeder, because it has done little to ensure a greater control in the selection and handling of material on the part of the breeder. Nevertheless, there are some aspects of cytological research which are of great interest and importance to particular breeding problems, as, for example, the chromosomal interpretation of species relationship, the conception of polyploidy, and the explanation of sterility and peculiar forms of inheritance.

Breeding programmes which involve the hybridization between species or even genera are based to some extent on the results of cytological research, because many of the difficulties and peculiar characteristics of these so-called "wide crosses" are bound up with chromosome behaviour. In many cases cytological investigation is a necessary adjunct to practical breeding work of this nature, and the identification of true-breeding and stable forms can be ascertained cytologically.

The conception and establishment of the phenomena of polyploidy is also of great use to the plant breeder. Polyploid forms, i.e., forms possessing more than the basic number of chromosomes, are, in general, characterized by greater variability than the basic forms, and some geneticists and cytologists believe that the artificial inducement of such polyploid forms should be a useful means of creating a greater variability in plant breeding material. It is often impossible to combine desirable characters of distantly-related forms by hybridization because of difficulties of crossing and sterility in the progeny. If any means could be found of inducing these desirable combinations a great service would be effected in certain types of plant breeding. There are many ways of inducing polyploidy in plants without hybridizing, e.g., exposure of plant tissues

to X-rays, chemicals, high temperature, low temperature, etc., but as yet little of practical use has resulted from such treatment, and hybridization remains the most important method.

MODERN TRENDS IN BREEDING TECHNIQUE.

If genetic and cytological research has only a very limited application to plant-breeding problems, it has at least opened up new possibilities in breeding technique. The standard method of selection in hybrid populations is in many ways the direct outcome of genetic research, while other methods such as that used at Svalöf, and the repeated back-crossing method, are modifications which have been evolved as genetic and cytological knowledge have increased. The Svalöf method has been used with considerable success, but the repeated back-crossing method, which is a means of transferring single characters from one form to an otherwise desirable type, is still in the experimental stage. The use of wide-crosses in hybridization is at present being tested all over the world, and was mentioned previously as a means of inducing a greater variability, and of producing new forms which are impossible by the hybridization of closely-related forms.

Wide-crosses, which may be interspecific, intergeneric, or between forms of the same species but with large difference in environmental requirements, are not to be indulged in lightly or in a speculative manner. They should only be attempted when close-breeding does not satisfy the requirements of the breeder. In this country, for example, wide-crosses have so far proved very disappointing, and more successful results have been obtained by close-breeding. The former method has been used both for the transference of single characters and for the inducement of polyploid forms.

An example of the successful use of the former procedure may be seen in the wheat variety Marquillo, which is a species hybrid possessing the disease resistance of one species, and the desirable agricultural characters of another. Sugar cane affords a good example of the second procedure, where the most profitable varieties at present grown are polyploid forms resulting from hybridization. It should be noted, however, that sugar cane is vegetatively propagated and thus escapes the complications of a sexually propagated crop.

Considerable interest is at present being shown in the intergeneric hybrids between wheat on the one hand and rye and couch grass (*Agropyrum*) on the other. The Russians have been the pioneers in this work, and they claim to have produced perennial wheats with extreme winter hardiness, resistance to bunt, smut and

ear shattering by this means. They also maintain that the greater earliness of these forms is extremely valuable to them in relieving the pressure of work at harvest time. Mention should also be made of the interspecific crosses in potatoes, where attempts are being made to transfer disease resistance, frost resistance and drought resistance from wild species to the cultivated forms.

Although perhaps the application of these wide-crosses is very limited, it is a new departure in breeding which demands careful consideration. The usefulness of such methods is very much dependent on the crop, the standard of agriculture, and the conditions which have to be catered for by the breeder. The Russians are developing their agriculture in a continent which has the widest range of environmental conditions which can support a great diversity of crops. They are endeavouring to produce new crops and new varieties which can be cultivated in areas which have either remained undeveloped because of unsuitability for cultivation, or else which are characterised by a low standard of agriculture. In those circumstances they can afford to adopt the larger view and exploit all possible means of creating new types, whereas in this country there is not the scope for these spectacular methods because the conditions are more equable, the varieties available are superior, and the diversity of crops is not so great.

However, it would be a short-sighted policy to ignore the possibilities of this new and experimental work in plant breeding, and interspecific crosses in wheat and oats are being investigated in this country as a practical means of crop improvement, while the more academic side of the inducement of polyploids in certain cruciferous plants is also being studied.

Conclusions.

The present position of plant breeding is one of extreme interest in relation to the influence of modern scientific research, in that the breeder is exploring the possibilities of incorporating the results of scientific work in his breeding technique. There is no doubt that genetic and cytological investigations have placed the breeder in a very much more favourable position than was the lot of the pre-Mendelian improver of cultivated plants, while physiological and agricultural research have given him a greater understanding of the material with which he works and the problems he must attempt to solve.

But granting the usefulness of the knowledge which has accrued from related branches of scientific research, is there any justification for assuming that plant breeding itself has become a science? In

other words, can the scientific precepts of related subjects be incorporated into plant breeding to such an extent that the importance of the personal element of the breeder himself is relegated to a secondary position?

The limited application of the important related sciences of cytology and genetics have been briefly pointed out above, because it is these two sciences which are most directly connected with plant breeding. But plant breeding can never become applied genetics nor applied cytology as some investigators imply. The aims of the cytologist, the geneticist and the plant breeder are quite distinct, but it follows from what has been said previously that the more genetic and cytological precepts can be incorporated into plant breeding the greater will be the control of the breeder over his material.

The plant breeder is often criticized by geneticists because he does not readily avail himself of the modern developments of genetical research. It has been recently stated that the old methods of plant breeding are worked out, and that new and improved varieties can only be produced by the application of such new and scientific methods as the artificial inducement of polyploids and mutations, and the use of wide-crosses.

In this connection the work of the Russian scientists is often quoted as an example of what may be done by such methods, but as has been pointed out, the problems of Russian agriculture cannot be compared with those of other countries where the conditions are so manifestly different. It should also be emphasized that agricultural plant breeding is not concerned with the production of monstrosities, or even with the production of something which only has the attribute of being "new." The aim of plant breeding is the production of *improved* forms of cultivated plants, or types which are suited to local conditions and specialized markets. In a country such as this, continuous intensive breeding of a refined type is far more likely to prove successful than speculative and spectacular methods which involve the breeder in a maze of uneconomic problems.

It is well worth while mentioning that some of the Russian workers engaged in investigations involving wide-crosses do not advocate the use of this method of plant improvement if plant breeding problems can be solved by the more refined method of close breeding. When improved types have been gradually evolved by intensive breeding in countries with a high standard of agricultural production, the breeder hesitates in embarking on speculative methods of possibly a limited economic value. In this connection it is interesting to realize that the Svalöf Plant Breeding Station,

which has produced an extraordinarily large number of improved cereal varieties, has employed intensive methods of breeding almost exclusively. It is also important to realize that the majority of the improved varieties of cereals grown in this and many other countries are all blood relations. But this does not mean that the possibilities of the newer methods are being ignored, and at the present moment most plant-breeding stations are organizing programmes of research based on modern genetic and cytological research.

Perhaps another example of the futility of attempting to generalize on the efficiency of various methods of plant breeding methods may be quoted. A new school of plant breeders has arisen in Russia which follows the teachings of the theory of vernalization with its scientific interpretation of plant development. Considerable benefits have apparently resulted from vernalization in parts of Russia, but investigators in many other countries have found little practical use for it up to the present. The actual practice of vernalizing crop plants is only regarded as a temporary expedient to be used while plant breeders are engaged in producing new varieties, but the theories which have been developed have been instrumental in causing some of the Russian breeders to deny the use of genetics in practical breeding, and to denounce the conception of the gene as a fallacy which is a direct hindrance to the breeder.

Such opinions, of course, will not be universally accepted by plant breeders, but the example serves to emphasize the position of plant breeding to-day. It is a time of exploration in which all possible means of exercising a greater control in methods of improvement are being tried.

In spite of all the scientific research in many fields of enquiry which undoubtedly must increase the useful knowledge available to the plant breeder, there is as yet nothing to substitute for the personal judgment and skill which are the means by which selection is practised in all forms of breeding.

The choice of parents, the selection of single plants, and the assessing of the value of hybrid cultures are, and must continue to be, the all-important procedures in hybridization technique. It is true that chemical tests are employed to aid the selection work in some breeding work; that controlled conditions and artificial infection of plants are utilized in breeding for disease resistance; and that yield trials on hybrid cultures can be conducted statistically. For the most part these aids to selection satisfy the conscience of the plant breeder by giving him evidence in black and white that

his selection is in the right direction. In the nature of the case, many of these tests can only be conducted when sufficient material is available after the critical work of early selection has been accomplished on eye judgment, while in the case of characters such as malting quality and bread-making quality there is at present no infallible test except the making of beer and the baking of bread respectively.

It seems, therefore, that in the final analysis, plant breeding continues to be largely an art, in the same way that agriculture itself is, dependent for its success on the judgment, experience and native skill of the breeder, who must continue to try and incorporate into his work the discoveries of a world which is striving, somewhat self-consciously, to be completely and wholly scientific.

THE BOTANICAL ASPECT OF SOME POULTRY PROBLEMS*

By D. H. Robinson

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At first sight it appears remarkable that botanists should have ignored for so long the turf poultry-run and the problems that it offers to the ecologist and others. But the intensive study of grasses in this country is only a quarter of a century old, and until very recently poultry keepers themselves have neither paid much attention to their grass nor asked that anyone else should interest himself in any scientific problems that might lie hidden in the turf.

With the discovery by Woodman and others of the protein-richness of young grass, and because of the extension of the system of folding poultry intensively on grassland, it becomes obvious that botanists and others will have to tackle a whole series of problems connected with the reaction of grass to the poultry, and what is perhaps more important, the reaction of poultry to grass.

It is the purpose of this paper not to produce results, but to indicate my ideas as to the scope of the investigations required.

It seems to me that the botanical, or more accurately biological, problems involved fall into two main groups. First, there are the problems connected with the small, more or less intensive, pens; and secondly, the problems which arise from the maintenance of poultry under extensive conditions, and the folding of birds in movable units.

To deal first with the small, or comparatively, small poultry pen, in which each bird has approximately 20 sq. yds. of space. There are, I suppose, two main reasons for wishing to maintain a turf in such runs. Turf keeps the birds cleaner than would bare ground, and grass provides green vegetable matter which most authorities agree is vital to healthy existence There is also the consideration that vegetation assists to remove the excess nitrogen added to the soil by the birds.

We can, perhaps, ignore the first consideration. To provide and maintain turf merely to keep the birds clean would be an expensive business, though it is possible that the aesthetic pleasure of a green sward may be appreciated even by a creature with such a small brain as the fowl.

* Paper read in December, 1936.

On the other count—that of the food value of the grass—we come right up against a wall of ignorance which does credit to no branch of agricultural science. So far as I can discover, no one knows how much green growing grass a hen is likely to consume during a working day. Practically all references to the amount of green food eaten by fowls deal not with grass, but with other things such as cabbage and kale. Further, in those few cases where attempts have been made to assess the consumption of grass, the grass has been cut or mown, and I do not think that one ought to rely too much upon this method of investigation. We very badly need some authoritative figures to give us an accurate idea of how much growing grass a hen will consume, and until we can get them we must necessarily suffer a handicap.

This matter of amount is closely linked up with the protein requirements of laying hens. Protein is expensive to buy, and the poultry keeper—having read about Woodman's work on the protein richness of young grass and its influence upon the rationing of farm livestock—quite naturally turns to educationists and asks, cannot you do something for us on similar lines?

At the moment we are not able to give a definite answer to even the simplest query concerning the value of grass to the hen. We suspect, but we do not know. At Dauntsey's School, for example, where rations rich in protein and rations low in protein, were fed to birds in different pens, it was found that the birds receiving the low protein ration were very much more severe upon the white clover, dandelions and miscellaneous weeds than were those fed on the high-protein ration. Moreover, there was twenty times as much herbage in the high protein pen as in the low protein pen. The conclusion is inescapeable that the fowls were trying to get additional protein by consuming more young clover, and more young grass.

These conclusions are strengthened by observations carried out in Wiltshire by Duckett, and by some tentative figures given by myself from the Harper Adams Laying Trials. I was able to show that, for one particular season, there was a correlation between egg production per pen and the length of the grass in the pens.

My point, however, is that we must have many more figures before we can feel safe in our conclusions. We ought not to dangle before the poultry keeper the prospect of cutting down expenses by reducing the protein of his ration until we can satisfy ourselves that the grass will provide this extra protein. For one thing, we do not know how long the turf will stand up to continuous grazing by protein-hungry birds: let us not forget that the grazing of poultry

and the grazing of farm stock are very different. To mention one point only—the farmer mixes his grazing stock, the poultry man uses one class only.

A great deal more investigation will have to be done on protein and other subjects before we can feel confident of prescribing properly for the poultry keeper wishing to lay down land to grass runs. We do know that the average seeds mixture as used on the farm is not suitable for the special needs of poultry. Red clover and alsike clover are useless, for these have no chance of surviving the beak of the hen. Cocksfoot and other tufted grasses are undesirable on several counts. But the prescriptions which have been suggested as suitable for poultry runs have not been compounded of any special knowledge. They have been compounded with the idea of forming a dwarf, lawn-like turf, easy to maintain and not too expensive to establish. It may turn out that these prescriptions cannot be improved upon, in which case no one will be better pleased than I, for I have been responsible for at least one of them: but until further careful experiments have been carried out it is impossible to feel happy about them.

We do not know which grasses are most palatable to poultry. We can, of course, obtain a pointer from our experience with farm livestock, but it is unwise to push the analogy too far. We badly need some experimental evidence on this matter if we are to make the fullest use of grass as a food for poultry. Is it true, for example, that perennial rye grass is liable to cause crop binding, and is it only the flowering stalk that is responsible? Ought we to compound a turf composed entirely of palatable species, or should the turf contain some non-palatable species to take the wear and so maintain a cover to the ground?

If it is agreed that the continuous grazing of poultry runs by hens alone is detrimental to the turf—and I think there is little dispute about this—what is the best method of dealing with the situation? Close mowing throughout the growing season is one way of preventing the herbage from becoming rank and setting seed, but it is not one much favoured or practised because of the labour involved. There is as yet no very satisfactory motor mower suitable for working in small pens.

The alternative is to use some other form of stock, and sheep at once suggest themselves. Sheep will undoubtedly do much to counteract the ill effects of continuous stocking by birds, but after a time they graze less and less efficiently, and the pens become "sheep sick." It would be very interesting to know exactly why this happens: is it due to the fouling of the turf by the birds or the sheep

themselves, to chemical change within the grass, to boredom, or to any other cause?

Geese have also been suggested as alternative stock for poultry pens, and observations suggest that, used in the right way, geese can improve poultry turf. Geese graze in a very different manner to hens, and do not scratch. They pull the grass more with their beaks, and their droppings have a different effect upon grass. There is scope here for much investigation by the agricultural botanist.

We should like to know more precisely the influence of different classes of poultry—fowls, geese and ducks—on different grass species, not only from the feeding-scratching point of view, but also from the point of view of the influence of their manure. At the moment we are extremely ill-informed concerning the influence on grasses of the dung of the different farm animals.

Stapledon, in an address at Harper Adams College in 1932 said, "It is a funny thing that as far as I know nobody has ever started in and manured grassland plots, some with the excreta of sheep, some with the excreta of horses, some with the excreta of cattle; what a pretty little experiment in applied ecology for somebody who has excellent powers of observation and a partiality for the Latin Square."

Had he included the excreta of poultry the experiment would have been even more beautiful. Actually a series of plots on these lines has recently been laid down by Bates at the Staffordshire Farm Institute, but I am not in a position to give details, and the experiment is so young that it might be unfair to make any deductions just yet.

It is desirable to keep the grass of poultry pens short for a reason other than the prevention of rank growth and interference with the exercise of the birds. Taylor, writing on the control of the spread of parasitic worms in poultry, says "considerable benefit may also be obtained by maintaining the grass of fowl-runs very short through hard grazing with sheep. Excrement falling into long grass remains moist for days, the air which is entangled there being more or less saturated with moisture, but excrement falling on to short grass is exposed to the ordinary atmosphere, to the drying action of air currents and of the sun, and has an opportunity of becoming dry before the larvæ reach the less vulnerable infective stage."

This point raises another: can turf runs be properly disinfected without killing the turf? This surely is almost as much a botanical problem as a zoological one, but since it raises highly controversial topics I do not feel like discussing it here. The question: Is the liming of poultry pens eye-wash as well as white wash? shows what I have in mind

Turning now to the use of folding units, we find an entirely new problem in applied botany waiting to be explored. The use of portable ranges measuring about 20 ft. by 3 ft., and holding twenty-five birds, has increased very considerably during the last year or two. Each unit is moved forward on to entirely untouched grass every day, and it is claimed that this procedure results in a very great improvement in the quality of the grass. The system is being carried on by Hosier on the thin turf of the Wiltshire Downs and also by farmers in some of the low-lying grass farms in other counties.

Under this system we have two factors at work on grass land which deserve the close attention of the agricultural botanist. First, there is the intensive scratching and tearing of the turf by the feet of the birds; and secondly, the even distribution of considerable quantities of a manure, concentrated, but relatively deficient in potash. It is extremely desirable that accurate observations should be made upon turf subjected to the unit folding system, the more so because it is being claimed in some quarters that by it relatively worthless grass may be wonderfully improved.

I do not think that this ecological problem is yet being investigated to any extent. Problems of this sort require a great deal of time, and those burdened during the summer with a full teaching programme have little chance of carrying out the work properly. I think a good case could be made out for the appointment of a research scholar whose business it would be to investigate the changes (if any) in grassland vegetation which take place during the folding of poultry. It would, at any rate, be a line of investigation likely to be quite as profitable as several now in progress for which grants in aid have been made.

There are other things, too, which the botanist would like to investigate if funds would allow. Is it correct that white clover will scour poultry, or affect the colour of the yolk of eggs? Does Yarrow affect birds in any way? Is poultry manure more likely or less likely to spread weed seeds than farm-yard manure? Does poultry manure have any special effect upon plants? What is the possibility of "scorching" plants with fresh poultry manure? What weeds are likely to crop up where poultry are run intensively, and why? Do poultry like certain grass seeds more than others, and has this any effect upon the grassland? Do grasses and clovers have any bearing on the earthworm population of poultry runs—and so on?

Obviously the poultry keeper offers enough botanical problems to keep many of us interestingly, and possibly, profitably employed for many years.

THE ANALYSIS AND COMPOSITION OF RYE GRASS*

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Analytical Methods.

The accurate analysis of agricultural materials is a matter of great practical importance. Frequently the chief concern is with one or two groups, but for some purposes a more complete statement of the composition of the material is required. This may be the case when the material in question is to be fed to animals, and the rations balanced up to some pre-determined level. Or alternatively, it may be desirable to know something of the developmental changes in the proportions of the chief constituents of some particular crop as growth proceeds, or as affected by environmental conditions. A system of analyses suitable for routine or semi-routine purposes is therefore required capable of picking out with some approach to accuracy the chief constituent groups of the plant.

The work to be described may be of interest from two angles. The first is that it provides an example of the use of some analytical methods not common in conventional practice, in an attempt to analyse directly for constituents known to be present instead of obtaining empirical fractions. The second is that it forms part of a study of the developmental changes in composition of grasses, the implications of which are obvious in view of the increasing use of crop driers for young grass.

The results of the analysis of such materials as grass by the standard methods ordinarily employed are often disappointing in that a high percentage of the substance remains unaccounted for. The sum of ash, crude protein, ether-soluble material, and crude fibre is frequently little more than 40 per cent., leaving nearly 60 per cent. to be described as "N-free extractives," or "soluble carbohydrates," or some similar non-committal title. An actual determination of hot-water-soluble material probably does not approach this figure, leaving unexplained this serious discrepancy.

If the actual composition of plant materials is considered with respect to the conventional methods of analysis, it is apparent that the latter fail particularly in accounting for the structural cell-wall constituents. This may not be serious in the case of a starchy grain in which this group does not represent more than a

* Substance of a paper read at the December meeting, 1936.

small proportion of the whole, but in mature forage crops the results may be so incomplete as to be misleading.

The crude fibre determination is ordinarily taken as a measure of the structural constituents of the plant. Any part that is not included in this fraction must help to swell the large indefinite figure to be obtained at the end by difference.

The chief structural constituents of the plant cell-wall are cellulose, lignin and the polyuronide hemicelluloses. Considering their properties with respect to the acid and alkaline treatments which the crude fibre determination involves, it is realized that almost all the hemicellulose, much of the lignin, and a portion of the cellulose, will pass into solution or be hydrolyzed. Analyses of the crude fibre fraction from a wide range of materials have confirmed this view, because the residue has been found to be nothing more than an impure cellulose. About 60–80 per cent. of the plant cellulose is usually recovered, together with a very variable amount of lignin. The proportion of these two constituents recovered is not constant for any particular material, which means that this figure is not a satisfactory basis for comparison when studying the changes in composition of developing material.

The most serious criticism of the conventional analyses is that when applied to feeding stuffs there is no measure of the lignin content. In maturing forage crops undergoing lignification the only evidence of change in structural constituents is the alteration in the crude fibre figures, to which the cellulose contributes the major part. Since the presence of lignin is believed to be at the very core of the question of digestibility, it is an essential of any method or system of evaluating the more resistant cell-wall constituents that all the lignin should be included. Indeed, a figure for lignin content would be of the greatest value in many digestibility studies.

The facts above provide the justification for the abandonment of the crude fibre determination in studying the composition of forage crops, substituting instead direct determination of cellulose and lignin, neither of which present any great difficulties. The cellulose determination is based on the well-known Cross and Bevan method, with the modification that the tissue is chlorinated in suspension in water. Lignin and other constituents are removed by boiling with hot sulphite. The lignin determination is perhaps easier but not so straightforward, as suitable precautions have to be taken to avoid serious interference caused by the presence of pentose-containing polysaccharides and proteins. Reliable and reproducible figures can however be obtained. The direct determination of the polyuronide hemicelluloses is a problem that remains

to be solved. For comparative purposes at present the most satisfactory expedient is to determine only the furfuraldehyde-yield of the pentose and uronic groups in these polysaccharides, and to treat that as a measure of the total hemicelluloses.

THE COMPOSITION OF RYE GRASS.

To obtain as full a picture as possible of the changes in composition of rye grass during growth, weekly samples were cut from early May until the end of July. The grass was Western Wolths in its first season. The produce of six plots, each one yard square, was taken every week at random from a 98 plot rectangle. The grass was cut with shears at surface level, heated briefly at 100° C. to inactivate enzymes, and finally dried in a drying room at about 30° C. One sample was cut and left on the ground for hay at the time when the Farm Manager judged the rest of the field to be ripe for hay.

Some of the more interesting of the results obtained are given in Table I.

TABLE I.

COMPOSITION OF RYE GRASS (WESTERN WOLTHS).

Expressed as per cent. on Oven-dry Material.

Sample No.	Date cut.	Crude protein.	Cellulose.	Lignin.	Furfural from hemi-celluloses.	Fructosan.
1	May 12	11·8	26·1	3·6	3·1	25·6
2	,, 19	9·3	26·4	4·7	4·3	26·9
3	,, 26	9·1	28·9	5·2	3·7	30·1
4	June 2	7·8	32·0	5·9	4·3	28·1
5	,, 9	6·9	32·2	7·0	4·9	26·8
6	,, 16	6·4	33·8	8·7	5·5	21·3
7	,, 22	6·0	40·4	9·0	6·3	17·0
Hay	,, 22–29	5·6	43·2	10·4	6·9	11·8
8	,, 30	5·4	38·3	9·1	6·3	14·7
9	July 7	4·7	39·9	9·6	7·1	12·6
10	,, 14	4·7	43·2	10·5	7·6	7·0
11	,, 20	4·2	47·1	11·2	8·3	5·7
12	,, 26	5·0	46·2	11·1	7·9	3·2
13	Sept. 21	6·7	48·8	16·4	8·6	0·4

The nitrogen changes are more or less what would be expected, a steady fall occurring as maturity is reached. It was perhaps a little surprising that no greater difference was found between samples 4 and 6 or 7, because in that period the dry weight of the grass per unit area approximately doubled. However, the analysis of soil samples taken weekly on the same plots by Dr. Richardson showed that there was at all times a sufficiency of available nitrogen. In

haymaking, nitrogen was certainly lost, in part because the grass was well soaked by a heavy storm when almost dry. As far as can be judged, the total losses in haymaking were not as heavy as has sometimes been stated. The yield figures were not sufficiently reliable to give satisfactory information on this point, but when estimated from the proportions of more resistant constituents present, the loss was in the neighbourhood of 10 per cent. A similar figure was obtained in work of the same type in the previous season.

The cellulose content increased more or less steadily from 26–46 per cent. with the exception of a spurt from 33·8–40·4 per cent. in the middle of June, just about the time the heads were ripening. There was no increase in dry weight after this time, even though the cellulose percentage increased. This implies the formation of cellulose from some other constituent. The extremely old sample left till late September was not appreciably higher in cellulose than other of the mature samples.

The lignin figures are interesting, but owing to imperfections in the method of lignin determination that need not be elaborated here, are probably slight over-estimates. Lignification is often spoken of as if it were a rapid or dramatic process occurring about the time of maturity, or as a senescent change. That is clearly not the case, for the deposition of lignin appears to occur gradually and steadily throughout the whole growing period. It seems probable that a relatively small change in lignin content considerably affects the digestibility of the tissue, as no big change in lignin was found to take place between the end of June and the end of July, during which period the availability of the grass must have been much reduced.

In the next column is given the yield of furfuraldehyde from the polyuronide hemicelluloses, which, as explained above, is taken as a measure of this group. From general experience it is probable that the actual hemicellulose contents are 2 to 2½ times these figures; that is, the hemicellulose content of the youngest material is probably of the order of 7 per cent. and of the mature material, approaching 20 per cent. The rate of increase in hemicellulose content, as judged from these figures, is relatively steady. Taking the three main structural constituents together, about 40 per cent. of the young plant is accounted for, this figure being approximately doubled in the mature plant.

The cold water extract of young rye grass contains considerable quantities of a fructose polysaccharide. The presence of fructosans, or lævans, in members of the Gramineæ has been reported at various times under such names as sinistrin, or graminin, but the amounts

have always been regarded as small. In rye grass at a young stage nearly one-third of the dry weight is fructosan, later disappearing as maturity is reached. This makes it probable that an important physiological rôle must be ascribed to this polysaccharide, which constitutes the chief carbohydrate reserve material. A similar fructosan has been found in young wheat and barley plants, falling rapidly in amount as the ears form. In this case the fructosan is apparently a purely temporary reserve, mobilized later for the rapid development of the grain.

The satisfactory determination of the fructosan gave a certain amount of trouble, but a two-stage method was finally devised whereby the fructose is titrated with the Shaffer–Somogyi micro-sugar reagent, before and after hydrolysis, a preliminary hypoiodite oxidation being given in each case to remove aldose sugars. The fructosan is hydrolyzed with extreme ease. Extensive hydrolysis may be effected by heating with oxalic acid as dilute as 0·05 per cent. for 15 minutes.

The fructosan is the only constituent of the rye grass which undergoes a major change in proportion during growth. High in the young samples, it falls rapidly with maturity. As far as can be said at present, the peak content occurs just about the time of full emergence of the head. Some variation in peak content may take place according to season, for in one preliminary sample taken in the previous season as much as 35 per cent. was found. Owing to the increasing plant weight, the peak content per cent. does not quite correspond with the maximum expressed as yield per unit area basis. The fructosan per acre reached its maximum at the time of the sixth sample, when it amounted to about 3½ cwt. per acre. It is probable that the fructosan is of great nutritional importance because of its high availability. There is some doubt as to whether it is split immediately by digestive enzymes, but even if not, micro-organisms in the intestines would certainly accomplish the breakdown and make it available.

The distribution of this polysaccharide within the plant was determined on the sample taken June 2nd. At that stage the head contained least, 17·3 per cent.; the leaves, 24·4 per cent.; the root, 25·0 per cent., and the stem most 35·4 per cent. The chief storage organ is apparently the stem. Analysis of the separate internodes showed that most is present in the first internode above ground level, 42·8 per cent., the next above containing only 34·1 per cent.

Further investigations will be necessary to elucidate the physiological rôle of this interesting constituent. There is, however, a

strong suggestion from the analyses that much of the temporarily stored fructosan is used subsequently for the production of structural constituents, particularly cellulose. Although no increase in plant weight occurred after the time of the sixth or seventh sample, there was nevertheless a steady rise thereafter in the structural constituents, and a concurrent and more or less comparable fall in the fructosan content.

These analyses establish that in annual rye grass the young grass differs from the mature in more than protein content, and that there is an alteration in type of carbohydrate present. Whereas in the older grass the carbohydrates are almost solely of the structural cell-wall type, in young grass there is a high proportion of an easily available fructosan so soluble as to be completely utilized without doubt.

It is therefore pertinent to inquire whether the advantages of feeding young grass are so exclusively centred in a higher protein content and greater digestibility of the unlignified cellulose as has been supposed.

Speculation on the implications of these findings in practice is probably premature, since a number of other important points remain to be investigated. The first is whether other varieties of grasses are similar to annual rye grass in fructosan content. That this is the case in all likelihood has been shown by demonstrating the presence of appreciable quantities of fructosan in good samples of meadow hay. The influence of a late application of nitrogen must be examined in case the grass can be kept longer in the young stage high in fructosan by this means. Seasonal effects must also be determined before a full picture can be obtained.

THE PRESENT POSITION OF DRIED GRASS, AND ITS USE AS A FODDER*

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For the purpose of this paper I wish to restrict my remarks to the feeding value of artificially dried grassland herbage, with particular reference to its use for the dairy cow. At Jealott's Hill we have studied the effect of artificial drying on the composition and digestibility of the fresh crop. The results were obtained on an experimental band dryer, operating with an inlet air temperature of 200° C. Under these conditions, the compositions of fresh material and finished product were almost identical, the only noticeable feature being an increase in the so-called "true" protein figures in the dried product. This is due more to the shortcomings of the analytical process than to any improvement in feeding value of the dried material.

The digestibility coefficients were satisfactory, and showed that the drying process had but little effect on the values for the original grass. The crude protein was slightly reduced in digestibility, but the depression was not serious.

The figures showed that under the conditions adopted in this set of experiments, artificial drying had not affected the composition as measured by the usual feeding stuffs analysis, nor had it depressed, the digestibility of the original material. The chief minerals calcium and phosphorus, were unaltered, at least in so far as quantity is concerned.

Vitamin Content.

In addition to these constituents, we have found that the most important compound present in the green crops is the plant pigment carotene, the precursor of vitamin A. Vitamin A does not appear to be present as such in the green crop, so that the carotene affords a good measure of the vitamin-A potency (as opposed to vitamin-A content).

A test carried out at Jealott's Hill on the dryer mentioned above showed that the retention of carotene was of a high order, the final product being rich in this constituent.

Of the other vitamins, the vitamin-B complex and vitamin D or its precursor do not appear to be present in large amounts,

* Substance of a paper read at the December meeting, 1936.

particularly the latter. We have obtained no information on either of these vitamins, but it is not to be expected that they would be harmed at the low temperatures reached by the grass itself in an efficient dryer. Vitamin C will undoubtedly be destroyed to a large extent, though modern work indicates that very rapid drying at really high temperatures may be less harmful to this vitamin than slower drying at lower temperatures. Here again we have obtained no information, nor do we know anything about the anti-sterility vitamin.

The question arises as to whether or not these findings are applicable to all types of dryers, operating over a wide range of *inlet* temperatures. A series of samples obtained from a number of dryers was examined, and the determination of the digestibility of the crude protein by *in vitro* methods and of the carotene content showed no difference between the dryers, due allowance being made for the fact that the original material was not directly comparable.

It would seem, therefore, that the inlet temperature has no effect on quality of material, and it was then decided to test the effect of direct exposure of dried grass to different temperatures for varying lengths of time. The results of these tests showed that exposure of dry material to hot gases resulted in a depression both of digestibility of the protein and carotene content, the latter showing the most marked difference. The higher the temperature to which the dry material is exposed, the more rapid the deterioration.

Dried grass usually shows no evidence of caramelization other than a certain pleasant smell in the material as it leaves the dryer. It is also relatively cool, and can be handled with comfort. The underlying reason, of course, is that the temperature of the crop can never rise to a harmful height so long as there is any moisture there to evaporate; the heat will be utilized for evaporation.

So long, therefore, as the material is taken from the dryer as soon as the moisture is sufficiently low and the dried material is not subjected to the action of hot gases, it is really immaterial what temperature is used.

The most important point in the use of any feeding stuff is to be able to assign to it the correct feeding value, particularly where highly productive stock are to be fed. We have examined a large number of samples of artificially dried grass at Jealott's Hill, and have determined their digestibility.

From the figures, curves can be drawn for starch equivalent and protein equivalent, plotting these values against the crude protein contents. The agreement is very good for protein equivalent, and sufficiently near for practical purposes for starch equivalent.

The samples displayed a wide range, varying from just over 10 per cent. to over 20 per cent. of crude protein in the dried grass, a variation which may arise on any farm according to the stage of maturity of the crop. It is impossible to assume that the whole of the dried grass produced on the farm will conform to one analysis —a very common error.

It must also be realized that by the very nature of things an arithmetical average will not give a true picture of the feeding value over the year; it must be a weighted mean. Much more of the material of lower crude protein content is produced than of the leafy high-protein crops, even under the best management. Another cause of error is the presence of any foggage or rough material in the bottom of a grass crop. It may look little, but the dry matter content is high (say 75 per cent.) whereas the young crop has a low dry matter content (say 20 per cent.), and when the whole is dried the adulteration is three and a quarter times greater than it appeared to the eye.

The carotene content of artificially dried grass is closely related to the crude protein. We have examined sixty-nine samples of dried grass varying in crude protein content from 9 to 20 per cent. (average 15·1) of the artificially dried material. The carotene content also covered a wide range, 10·4 mgrms. to 48·8 mgrms. per 100 grms., with an average of 25·8 mgrms. The correlation coefficient, r, was + ·816, a highly significant value (odds of 100: 1 need ·302). This material was from bales; if the dried grass is kept loose, the values would be reduced in direct proportion to the degree of compaction and exclusion of air, light and heat.

Crops such as Lucerne do not show the same variation, and an analysis of the material at the correct stage of growth in each cut would be applicable without great error to the whole of the material cut at that stage.

Types of Dried Grass.

With farm-dried grass, in practice it will prove advisable to classify the material, and there might well be three types—first quality, second quality and super hay. The first quality is of the same balance as a balanced dairy ration, 3 lb. of the latter equalling about 4 lb. of the dried grass.

At the other end of the scale is super hay, with the same balance between starch and protein equivalents as the figures given in "Rations for Livestock" for good meadow hay, and which are usually accepted for average meadow hay. The super hay needs

only 1 lb. to replace 1½ lb. of meadow hay. A new standard is suggested for average hay, and is based on a series of analyses and digestibility trials carried out at Jealott's Hill on twenty-four samples of hay obtained in the winter of 1935 as representative of good average hay. We found, as have workers at Wye, that the protein contents in the literature are too high, and suggest that 3·1 per cent. of protein equivalent is a fairer figure. This gives a still greater advantage to the super hay.

As a matter of interest, the feeding values of 30 lb. of the three types of dried grass have been worked out. The possibilities of dried grass are somewhat surprising. To ensure good results, however, it is imperative to be able to assign the dried grass to its correct class. On the other hand, it is well known that the standards in everyday use allow a good margin and, except in the case of the high-yielding cows the ill-effects of bad judgment may not be so dangerous as might be thought.

It is necessary for the farmer drying grass on his own farm to teach himself to classify his product, and it must be stored in such a way that all qualities can be drawn from at the same time. The best quality would normally be used only for the highest yielding cows, and the lowest quality for the cows at the end of their lactation.

FEEDING EXPERIMENTS.

Dairy Cows.—Our first feeding test with artificially dried grass was carried out in 1929 with five cows, replacing the cake allowance by an equal weight of dried grass of 18 to 21 per cent. protein content for all milk produced over 1½ gallons. The cows received from 5½ up to 10½ lb. of dried grass, and ate it readily, but only a small quantity of 5 cwt. was available, and the trial lasted about a fortnight. No more can be said of this trial than that there was no marked fall in milk yield. It did establish the fact that dairy cows would eat the material readily.

The next trial was devoted to a test of the effect of dried grass on the colour of milk, and was carried out in the winter of 1931–32 with four groups of four cows each. Over 70 per cent.—2½ lb. per gallon—of the production ration was replaced by artificially dried grass with 20·5 per cent. of crude protein (in the dry matter). The effects on the yellow colour of the butter-fat were striking, and in mid-winter the colour was kept up at a high level by including the dried grass in the ration. When feeding of dried grass was discontinued, the yellow colour of the milk fell rapidly to the level of the control group. When the cows were turned out to pasture, the colour rose again very rapidly to a high level.

The yellow colour of the butter was found to be directly proportional to the carotene content of the butter-fat, and also to its true vitamin-A content. In this experiment it was found that the vitamin-D content of the butters of all four groups was low throughout the winter, and did not rise again till the cows went out to pasture. The fat and non-fatty solids content of the milk showed no differences due to treatment, and the milk yields were maintained well.

In the following year, lower rates of addition of dried grassland herbage were tested, 10, 25 and 50 per cent. of the production ration being replaced by a sample which contained 17·80 per cent. of crude protein and 35·9 mgrms. of carotene per 100 grm. of dry matter. The two low rates of substitution of the production ration did not have any beneficial effect on the yellow colour of the butter-fat, as compared with a control diet of hay and concentrates. When half of the production ration was composed of this sample of dried grass, the yellow colour increased, though not to the maximum possible.

The earlier experiments had all been carried out with Shorthorn cows, but it was found in 1932–33 that all breeds do not react to the same degree to carotene in the diet, in so far as its action on the yellow colour of the butter-fat is concerned. Whilst all breeds show an increase in the yellow colour of the butter-fat with greater carotene intake, there seems to be a "ceiling value" set to the colour intensity, above which it does not rise, however rich the ration may be in carotene. It is necessary to know the breed before the actual depth of colour can be interpreted. The Jersey will always give a deeper yellow colour in the butter-fat than the Shorthorn, and the Ayrshire will give a still paler colour. The total biological value, due to carotene and true vitamin A, has been shown by other workers to be the same for all butters produced on the same diet.

In the winter of 1933–34 an experiment was carried out designed to measure the effect of dried grass on yield of milk. A dried grass with 17·46 per cent. of crude protein was obtained. It was in a ground form, and contained 20 mgrms. of carotene, which is somewhat below the value expected for this quality of grass. There were two groups of ten cows each, made up of four breeds, two Guernsey, two Friesians, two Ayrshires and four Shorthorns. It had originally been intended to include a fifth breed, but this proved to be impossible.

It had been hoped to feed large quantities of dried grass, but for mechanical reasons that did not prove possible. The ground

material was too dusty and, indeed, had to be moistened before it was eaten at all. This is a difficulty inherent on ground material, which does not arise with other forms of dried grass or even with the same sample when fed long. The amount of dried grass fed was 8 lb. per head daily for three of the breeds, and 10 lb. for the Channel Island cows. These amounts were eaten readily.

The experiment consisted of four change-over periods, each of five weeks. There was no significant difference in the milk yield between the two rations throughout the experiment, showing that in so far as yield was concerned the dried grass had produced the quantity which was to be expected from its analysis and digestibility.

There were no significant differences between treatments for fall in yield per week, fat content of milk, or solids-not-fat content of the milk. The live weights of the cows showed a significant advantage in favour of dried grass, from which it may be argued that this treatment had a beneficial effect on the condition of the cows. The ration for maintenance contained 6·0 lb. of starch equivalent and 0·6 lb. of protein equivalent per 1,000 lb. live weight. The requirements per gallon were reduced to 2·5 lb. starch equivalent for Channel Island cows, and 2·0 lb. for other breeds, and protein equivalent to 0·6 to 0·5 for the Guernsey and 0·5 to 0·45 lb. per gallon for other breeds. The effect of the ration on yellow colour of the butter-fat was significant, but not so marked as in previous experiments with their longer periods. The inclusion of artificially dried grass always resulted in an increase in the depth of yellow colour, whilst on changing back to the ordinary winter ration of hay and concentrates the colour of the butter-fat became paler.

In the winter of 1934–35 another experiment was carried out, this time with Shorthorn cows only. The artificially dried grass contained 18·33 per cent. of crude protein in the dry matter, with 31·3 mgrms. of carotene per 100 grm. of dried grass. The rations fed were 6·0 lb. starch equivalent and 0·6 lb. protein equivalent for 1,200 lb. live weight, and 2·25 lb. of starch equivalent and 0·5 lb. protein equivalent per gallon of milk produced.

The type of experiment was altered to one with a short pre-experimental period followed by a seventeen-week experimental period, the cows being divided into blocks distributed at random in the cowshed. There was no significant difference in milk yield between the control group and that receiving dried grass. It had been hoped to feed large amounts of dried grass, but in one of the comparative silage treatments one cow would not eat a heavy

ration of silage, and all treatments were scaled down to this. As a result, the average amount of dried grass fed was 8·6 lb., together with 1·4 lb. of a concentrate mixture. The artificially dried grass actually supplied 51 per cent. of the total digestible protein in the daily ration.

The effect on the quality of milk was included in the test. The fat content showed no significant difference between the artificially dried grass and control rations, and there was no significant difference in the content of solids-not-fat. The figure for solids-not-fat content, however, was above the legal standard for the dried grass group, and for no one of the other treatments, and there was a significant difference between the artificially dried grass and A.I.V. silage treatments.

The loss of weight of the cows was not significantly different between the groups. It should be remembered in this connection that the ration was reduced to the lowest possible level in order to allow any differences in feeding value between treatments to show. No one of the losses was significant, however, and it was found that the heavier cows tended to lose weight more readily than the lighter cows, which increased in weight in many cases. The use of artificially dried grass resulted in the production of a milk of higher yellow colour than where the control ration of hay and concentrates was fed.

Pigs.—Dr. Crowther, at Harper Adams, has tested dried grass in the feeding of pigs. The samples were of low crude protein content, and he summarised his findings as follows:—

> "On reviewing the whole experiment we are left with the general impression that the possibilities of replacement of sharps in pig rations by dried grass of the quality here used are small, and subject to a maximum limitation of about 10 to 15 per cent. of the total ration. For the earlier stages of feeding probably an even lower limit should be imposed. This impression has been confirmed by subsequent experience with a better sample of dried grass, and is also in accordance with the digestibility work recently published by Woodman."

Poultry.—Trials have also been carried out on poultry, in which 10, 20 and 30 per cent. of the ration was made up of dried grass. The egg yields were much the same on all rations, but the yolk colour was deeper in the eggs obtained from the birds on dried grass. This was found to be due to increases in the xanthophyll content of the yolk, not to carotene.

Other Observations.

This exhausts the accurate information available on the feeding of dried grass. It will be seen that no one of these experiments has investigated the effect of complete replacement of the usual foods by dried grass. At a farm in Cheshire this has been done for the last two winters, apparently with every degree of success. According to available information, the cows have milked well, kept in good condition and produced good calves. Since April, 1935, the cows have been fed on pasture in summer and dried grass and hay in winter, with no concentrates. From the autumn of that year the calves were fed on dried grass, the milk being stopped at eight weeks old. Dairy cows receive $4\frac{1}{2}$ lb. of dried grass per gallon of milk. No scouring or constipation has been noticed. Cows that have been used to concentrates, such as newly-bought cows in winter, take some little time to become used to a large ration of dried grass.

Young Stock.—For young stock, dried grass appears to be an excellent food, and has given good results. Calves fed on it have grown well, and have shown a good thriving condition, the coat being noticeably brighter. No published information is yet available on these points. It might be expected, however, that young stock would do well on dried grass, since it is a valuable source of vitamin A and should, therefore, stimulate growth and tend to keep the animals healthy. Calves should receive the best quality material. As they grow older, the quality fed can be reduced, till finally super hay (third quality dried grass) is used.

Fattening Stock.—This leads to the feeding of fattening stock. Here again there are no accurate published data. Theoretically the lowest quality of dried grass should suffice to finish off a fattening beast, but at this time the appetite is not quite so brisk, and this may call for the feeding of a better quality grass, with some degree of waste of protein if good results are to be obtained.

At a farm in Shropshire, dried grass has been fed to Hereford bullocks for the last two years. The results of a large number of weighings have been examined. It was concluded that the average live weight increase with all bullocks was of the order of 2 to $2\frac{1}{2}$ lb. per head daily, irrespective of whether dried grass was included in the ration or not. The main type of ration fed consisted of some 8 to 12 lb. of artificially dried grass or clover with good oat straw *ad lib.* and, when straw was short, some poor quality hay. The cattle all graded well but, especially in winter, it is thought that it may prove desirable to feed a ration in the later stages of fattening

designed to harden the fat somewhat. All the rations fed probably supplied an excess of nutrients, and it is therefore impossible to compare them critically.

Sheep.—For sheep again we have only practical evidence. The use of dried grass before and at lambing time is a valuable aid to the shepherd, and helps the ewes considerably. By analogy with the dairy cow it would be expected that it would be a good food for milk production. In autumn too it is useful for flushing the ewes if green keep is somewhat short. For lambs, as for all young stock, it should be a good food by virtue of its carotene content.

Horses.—The information on the feeding of dried grass to horses is negligible. It should be an excellent food for breeding and young stock, particularly if it is made from herbage obtained from land properly managed so that it is not deficient in minerals.

At Jealott's Hill we have replaced the oats in the ration of horses at light work by dried grass, and it has been eaten readily in these amounts. We are unable to say anything more definite about the use of dried crops for horses, but it should prove a useful food for such stock.

CONCLUSIONS.

To summarize, it may be said that artificial drying gives a product equal in feeding value to the original crop. Its use in the feeding of stock will therefore be decided by the advantages or limitations of the original material. We know that it can be fed to the dairy cow with every success, and the problem here is one of management, to get good quality material and adequate experience to be able to recognize the variations and the capacity to store and use them separately. There are indications that there are limits beyond which it cannot be fed to the pig. It is a safe and excellent food for young stock. There is a dearth of accurate information in its use for such stock, other than observational data, and this also applies to older and fattening stock. Its use for sheep seems promising, and it is eaten readily. We know little about its value for horses. It is obvious, therefore, that a good deal of accurate work is still needed in the feeding of dried grass, but the main problems are, first, the economic one of reducing cost of production to the lowest possible level and, second, the proper management of the grassland to produce the greatest bulk of the most valuable fodder.

THE EFFECT OF HEAT ON THE NUTRITIVE VALUE OF MILK*

BY S. K. KON

The National Institute for Research in Dairying, University of Reading

The effect of commercial pasteurisation by the "holder" method on the nutritive value of milk as measured by laboratory methods has been the subject of a recent extensive enquiry carried out in this Institute. This work formed a part of a wider scheme of research on the relative values of raw and pasteurized milks, sponsored by the Milk Nutrition Committee.[1]

The full report giving the detailed results of the laboratory experiments carried out here and at the Rowett Institute has just been published.[2]

In planning the work it was decided to study the behaviour of the constituents of milk which had been reported to be affected by pasteurization, or which were believed to be heat labile.† The investigation was not confined to the vitamins, but important constituents of milk, the salts and proteins, were studied as well. Rats were used as experimental animals but, where possible, vitamins were measured in physical and chemical tests. At Reading the milks were obtained from a local commercial dairy. The pasteurization was carried out by the holder method in an A.P.V. pasteurizer. The efficiency of pasteurization was checked by Kay and Graham's[3] phosphatase test.

The following experiments were done:—

(1) *Raw and Commercially Pasteurized Milks as Sources of Calcium and Phosphorus for the Growing Rat.*

Twelve pairs of litter-mate rats of the same sex (six pairs of does and six pairs of bucks) were given a basal diet very low in calcium and phosphorus, but otherwise adequate. Sub-optimal amounts of calcium and phosphorus (about 60 and 70 per cent. respectively of the normal requirements) were given to the rats in the form of milk. One member of each pair received the milk raw, while the other was given milk from the same bulk after commercial pasteurization. Food and milk intakes were equalized within pairs. The experiment lasted for five weeks, and the intakes of calcium

* Based on a paper read at the December meeting, 1936.

† A review of the literature dealing with the effect of heat-treatment on the value of milk as food will be found in the monograph of Stirling and Blackwood (4) and in two reviews by Kon (5), (6).

and phosphorus in diet and milk as well as their excretion in urine and fæces were measured. In addition, litter-mates of the experimental animals were analysed at the beginning of the experiment, and the experimental animals themselves were similarly analysed at the end. In this way two independent measurements of the assimilation of calcium and phosphorus were obtained.

It was found that the rats retained some 80 per cent. of the ingested calcium and phosphorus irrespective of the type of milk given. Statistical treatment of the results showed that, under the conditions of the experiment, commercial pasteurization had no deleterious effects on the availability of the calcium or of the phosphorus of milk. These results were fully confirmed in similar experiments carried out at the Rowett Research Institute, Aberdeen.

(2) *The Effect of Commercial Pasteurization on the Biological Value and Digestibility of the Proteins (Nitrogen) of Milk.*

In these experiments the biological values and true digestibilities of the proteins of raw and commercially pasteurized milks from the same bulk were compared on rats by the method of Mitchell[7]. Twelve female rats were used and data for raw and pasteurized milk were obtained on each rat. It was found that neither the biological value nor the digestibility had been altered by the heat-treatment.

(3) *The Effect of Commercial Pasteurization on the Vitamin A and Carotene Content of Milk.*

These factors were estimated by physical and chemical tests on butters churned from the raw and pasteurized milks. Lovibond tintometer tests were done in Shinfield and spectrophotometric readings were taken by Mr. A. E. Gillam at Manchester University. In all, ten samples of "raw" and ten samples of "pasteurized" butter were compared, and it was found that no vitamin A or carotene was destroyed in the course of pasteurization.

(4) *The Effect of Commercial Pasteurization on the Vitamin B Complex of Milk.*

Young rats of both sexes were "run out" of their vitamin B reserves on a suitable diet. Seventeen pairs of litter-mate bucks and thirteen pairs of litter-mate does were then selected, and members of each pair were allotted by toss of coin to raw or pasteurized milk. Each rat was allowed unlimited access to the vitamin B complex deficient diet, and was given in addition 8 ml. daily (except Sundays) of raw or of pasteurized milk. This was continued for eight weeks and the rats were weighed twice weekly. At the end of the experiment there was no appreciable difference in weight between females on raw and those on pasteurized milk. Male rats grow more rapidly

than females and the males receiving raw milk were, at the close of the experiment, definitely heavier than those on pasteurized milk. This difference was of definite statistical significance, and showed that the vitamin B complex of milk had suffered some loss in the course of pasteurization.

(5) *The Effect of Commercial Pasteurization on the Vitamin C of Milk.*

Vitamin C was estimated chemically over a period of four months in the raw and pasteurized milks by titration with 2-6-dichlorophenol-indophenol. The average figures showed that about one-fifth of the vitamin C originally present in milk had been destroyed in the course of pasteurization.

(6) *Comparison of the Total Nutritive Value of Raw and Commercially Pasteurized Milks.*

Raw and pasteurized milks, supplemented with iron, copper (to prevent nutritional anæmia) and manganese were fed in equal amounts to pairs of litter-mate male rats. Two experiments were carried out; one lasted eight weeks, the other six months. No difference was found in either of them in the growth and composition of carcases of the rats on raw milk, and of those on pasteurized milk.

When milk (supplemented by minerals) is fed to rats as the sole source of nourishment, the level of intake is so high that the known constituents of milk required by the rat are available either in great excess, or at least with a good margin of safety, and the effects of pasteurization would have to be very severe to become manifest under such conditions. The results quoted above show that the more unstable factors of milk are not seriously affected. The outcome of the experiment on the effect of pasteurization on the total nutritive value of milk suggests that no unknown essential constituent has been drastically reduced by the treatment.

In conclusion it may be said that the laboratory experiments just described failed to disclose any marked loss in the value of milk as food which could be attributed to properly carried out commercial pasteurization by the "holder" method.

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OBITUARY

ERNEST GARNSEY

By the death of Major Ernest Garnsey, which occurred in December last, agricultural education lost the help of a man who was deeply interested in its welfare. For the last twelve years of his life he was a Principal in the Education Department of the Ministry of Agriculture, and to his earnestness, ability, tact and initiative is due much of the advance which agricultural education has made during recent times.

As an example, as well as inspiration, a brief sketch of Garnsey's career is worth the making.

Born at Wellington, Somerset, on 9th March, 1876, he was the second son of the late Mr. W. S. Garnsey, and elder brother of the late Sir Gilbert Garnsey, F.C.A. In 1888 he entered Wellington School, where it is said of him, "he quickly made his mark by his intense industry." In 1892 he entered the Agricultural Department of Armstrong College, from which in due course he took the degree of M.Sc. Following a brief period as Science Master in Falmouth Grammar School, he entered the University of Cambridge as a foundation scholar of Caius College, where he took a first-class natural science tripos, being placed second on the list. From Cambridge it seems that he accepted the position of Senior Science Master at Merchant Taylors School, London, and remained there until he entered the then Board of Agriculture in 1903. He became a member of the Agricultural Education Association the same year.

Tersely put, Garnsey's career at the Board (later the Ministry) of Agriculture was as follows:—

1903 to 1912, Inspector of Agricultural Education.
1912 to 1914, General Inspector of Horticulture.
1919 to 1920, Private Secretary to the Parliamentary Secretary.
1920 (part of), Head of the Horticultural Branch.
1920 to 1924, a Principal in the Fisheries Department.
1924 until his death in 1936, a Principal in the Education Branch.

During the earlier years of his time with the Board Garnsey read for, and eventually was called to, the Bar, taking his LL.B. at Cambridge.

Whilst he was at Caius College from 1898 Garnsey took a keen interest in military training and held a Commission in the Cambridge

Volunteer Rifles. This interest was later transferred to the Honourable Artillery Company, of which he became a Member, and when war broke out in 1914 it was with this Company that Garnsey proceeded to France, where he remained until 1919. While in France he was mentioned in despatches, decorated by the French with the Croix de Guerre for his services at Bailleul, and for a part of the time held the position of Assistant Provost Marshal to the Fifth Company.

Referring back to Garnsey's time at the Ministry, it may be said that it was from 1924—the time when he entered into the administrative field of the education branch—that he found the work in which he revelled. Keenly interested though he undoubtedly was in every branch of that work, it is probably true to say that there were two sections which seemed to occupy the warmest corner of his heart and to which he devoted assiduous attention; they were the scholarship scheme for the sons and daughters of agricultural workers, and the promotion of farm institutes.

Those of use who knew Garnsey intimately will always remember him as a true friend and an agreeable colleague. Always accessible, always sympathetic, always encouraging and always helpful so far as within his power lay.

J. F. B.

THOMAS HACKING

The career of Thomas Hacking was a further example of one who triumphed over difficulties. His passing in April, within so short a period of his retirement, occasioned great regret amongst those with whom he had worked in the sphere of agricultural education, especially as he himself had looked forward to some years of retirement in which he could interest himself to his heart's desire in archaeological studies.

Born at Nelson in March, 1870, Hacking was a half-timer in a Lancashire cotton mill at ten years of age. His early education was received at night schools, which he attended without the knowledge of his parents. Having formed an early interest in agriculture, he was successful in obtaining a scholarship to the Harris Institute at Preston, and from there obtained a further scholarship to the Durham University College of Science (now Armstrong College), Newcastle-upon-Tyne. He was admitted to the A.Sc. in 1897 and in the following year he obtained the first place

in the R.A.S.E.'s diploma examination, being awarded the Gold Medal and Life Membership of the Society, having obtained 1,154 marks out of a total of 1,500 in the examination. Following the reconstitution of the University of Durham, when University degrees in Science were recognized, Hacking obtained his B.Sc. in 1910 and the M.Sc. in 1913.

His first agricultural post was that of Record Keeper at the Northumberland Agricultural Experimental Station, Cockle Park, and in association with Somerville he was responsible for the laying out of the first experimental plots at that station. This early experience at Cockle Park, and the close contact that he made with Somerville, left a lasting impression on his life. To the end of his days he remained a true lover of Northumberland and it was perhaps fitting that his last months were spent in Newcastle, so near to the scene of his early labours. During his student days he became interested in archaeology and Hadrian's Wall in particular, and much of his leisure was spent on the Wall during the period that he was in Northumberland. This interest claimed much of his leisure in later years, and he lost no opportunity to visit the sites of old Roman encampments and villages, while it was an education to spend a morning with him at the British Museum where he was to be found very frequently when in town.

His later agricultural posts included those of the Principal of the Dunmow School in Essex followed by his appointment as the Agricultural expert and lecturer under the East Sussex Education Committee. He was appointed Agricultural Organizer for Leicestershire in 1913 in which county he served for 23 years. During the period of the war he was Chief Agricultural Officer for the County, and his experiences during this time caused him to take an interest in legal matters. It says much for his breadth of outlook and his capacity for work, that he qualified for the bar and became a barrister-at-law after the war. It was one of Hacking's characteristics that if he wanted to know something well he believed in studying the subject with a view to gaining the appropriate qualifications. This is illustrated by the fact that he once sat and passed the examinations for a Sanitary Inspector. His work in Leicestershire will always stand as a memorial to him. The problems that he had to face were not simple. As Chief Executive Officer of the Leicestershire War Agricultural Committee it fell to him to carry out the committee's programme of ploughing out many thousands of acres of Leicestershire renowned grass lands. It was in this work that he displayed some of his finer characteristics. His sympathy and his friendly relationships with all who were called

upon to make sacrifices are still remembered, while he was always scrupulously fair in his judgments.

He became recognized as a guide, philosopher and friend to the farmers in his county, and his advice was sought and given freely not only on official matters, but on the more intimate problems of life. In all his work he revealed an intense love for the land, and a desire to do all that he could to assist those engaged in the agricultural industry. Many young men owe their start on an agricultural career to his advice and guidance and many enjoyed his friendship. The successes of students from his county at the Midland Agricultural College were a personal matter to him, and he never spared himself in giving help to them whenever they were in difficulties. He was essentially a young farmers' man, and he regarded as his best work in the county of Leicestershire the development of a series of Young Farmers' Discussion Societies which cover all the principal centres of the county.

Members of the Agricultural Education Association know already the active part that he played in this; he was honoured by the Presidency in 1934. He also represented his county on the Agricultural Committee of the County Councils' Association and no speaker commanded greater respect.

Hacking possessed a depth of character that stamped him as an outstanding leader of men. He was keenly interested in the Adult School movement and the Sunday afternoon addresses that he gave to the members of the Victoria Road Church Adult School, Leicester were a testimony of his life. He was a firm friend and a true colleague, and he had the capacity of doing good without making a fuss. Even in his last illness he maintained a cheerfulness and courage that were inspiring and the commencement of his illness was the result of devotion to duty. His loyalty to his old college led him to present the whole of his library of 2,000 volumes to Armstrong College.

Agricultural Education can ill afford to lose such men as Thomas Hacking, but his work remains. H. G. R.

JOHN CARTWRIGHT RUSHTON

John Rushton, who died only a few months after his retirement, in 1935, was the son of a Staffordshire farmer living at Rush Slade Farm, Hilderstone. He attended the local school, became a pupil teacher and then an assistant at St. John's Boy's School at Burslem. In 1894, however, he forsook elementary education and went to the University of Edinburgh to study agriculture. He remained there until 1897, and though he did not graduate he obtained various certificates and became a life member of the Highland and Agricultural Society.

On leaving Edinburgh Rushton returned to Staffordshire as Agricultural Instructor under the old County Technical Instruction Committee, afterwards merged into the Education Committee. He became a member of the Agricultural Education Association in 1903, and in 1935 was elected to Honorary Membership in recognition of his long services.

The story of Rushton's life is practically the story of the steady and firm evolution of agricultural education in his native county. Progress was not slow, as in 1913 the whole scheme for a farm institute had been approved, the land had been bought, and the plans sanctioned, but 4th August, 1914, intervened, and it was not until 1921 that the present Farm Institute (Rodbaston) was opened. From the first it was a success; its reputation was enhanced by the improvements made to the then existing farm buildings and by the formation of their herds of Dairy Shorthorns and Large White Pigs. Yet the Institute was Rushton in the eyes of the farming folk.

Rushton was a friendly individual, quiet and unassuming, and one who could tell a good story. He was very sound and steadfast, and one of those whose thorough spadework and foundation laying enables the younger generation to make agricultural education progress at an ever-accelerating speed. E. D.

REVIEWS

British Grasses and their Employment in Agriculture. By S. F. Armstrong, M.A. Pp. ix + 350. Third Edition. (Cambridge University Press.) Price 15s.

This book was first published in 1917 and reprinted in 1921. The present edition has been revised and entirely re-set: it is beautifully printed on high quality paper and produced in a manner which reflects great credit on the publishers.

It is divided into two parts. Part I, occupying 160 pages, deals with the Morphology, General Biology, Distribution and Botanical Description of British grasses. The preliminary chapters in this section form an admirable introduction to the study of grasses, and provide in an extremely lucid manner all the information that the average agricultural student is likely to require on this subject. In Chapter IV there is a key to the common grasses based upon foliage characters, and in Chapter V a key based upon floral characters. Probably every teacher has his own idea as to the ideal key for the recognition of grasses: the two keys provided here should enable the intelligent student to identify his species at least as well as any other artificial method. There is also a useful illustrated key to the grass seeds.

Chapter VII, covering over 100 pages is, in the opinion of the reviewer, the most valuable of the whole book. It is a botanical description of the common grasses arranged in alphabetical order of their genera. This arrangement is, in a work of this sort, infinitely preferable to any "natural" arrangement, as it facilitates easy reference. There is no other book which gives such accurate, full and easily understood descriptions of British grasses as those contained in this chapter. Each species is illustrated by photographs and line drawings, which make identification as simple and as certain as is possible. This chapter alone makes Armstrong's book quite indispensable to the agricultural botanist.

Part II, the Agricultural Section, has been re-written and enlarged "with the object of giving more fully the results of recent research on grasses and grassland." A great deal of information has been packed into this section, dealing not only with the agricultural use of the different species and strains, but also with their seeds and the impurities which may occur in samples. There is a useful chapter on Seed Mixtures, though the minor criticism may be advanced that the question of cost does not receive much attention. Grassland Management occupies pp. 256–284, and a valuable feature of this and other chapters is the references to recent literature which are given. Chapters dealing with the Improvement of Poor Grassland, with Lawns and with the Valuation and Purchase of Grass Seeds add to the value of the book, though it is perhaps open to doubt if the "Real Value" method of seed sample comparison has any real value.

British Grasses in its new form is even more attractive and useful than before, and can be strongly recommended to all who are interested in modern agriculture.

D. H. R.

Leguminous Forage Plants. By D. H. Robinson, Ph.D., B.Sc., N.D.A., Pp. vi + 110. (London, Edward Arnold & Co.) 1937. Price 6s.

This little book is intended to enable those who are interested in leguminous forage plants to recognize them at the various stages of growth. Descriptions and very useful drawings of the growing plants are given for 21 species, and if one has some idea of the possible identity of any of these species it is easy to obtain an authoritative verdict from this book. No attempt has been made to summarize the distinguishing characters of the various genera or species.

We must be grateful to Dr. Robinson for collecting together so much information that was previously only available in a scattered form. This book should be very useful in classes reading for pass degrees and the National Diploma in Agriculture and also in the more general type of farm institute and county evening class. It is, however, regrettable that no bibliography is available to those who seek fuller information. When such outstanding works exist as Erith's monograph on white clover and William's bulletins on red clover this omission is particularly unfortunate, and we hope that a list of references will be included with a later edition.

The information is mainly well summarized and a short glossary explains the botanical terms which are included. It is not clear why Cotswold strains of red clover are described as "very reliable croppers for all types of soil" while Swedish strains are "not recommended" and it is doubtful whether Trefoil will grow on most soils as is stated on p. 58. It is stated on p. 57 with reference to Trefoil plants that "they are free from hairs." This presumably applies to the leaflets, which are generally pubescent. No notes are given for the identification of the smaller clovers, other than T. dubium, which are of interest in relation to white clover seed samples, although room is found for Burnet.

Some useful seed statistics are included but there is no mention of soil germination percentages, although considerable work has been done with leguminous species. The figures for the chemical composition and percentage of digestible nutrients at various stages of growth, which are given for the principal species, are a valuable feature of this work. F. R. H.

Vegetable Crops for Market. By A. H. Hoare. Foreword by Sir William Lobjoit, O.B.E., V.M.H., J.P. Pp. 198 with 36 illustrations. (Crosby Lockwood & Son, Ltd.) 1937. Price 7s. 6d.

The author has crowded into the body of this book a condensed survey of brassica, leguminous, root, salad, miscellaneous, early and forced crops, and culinary herbs, including a descriptive account of methods of cultivation, manuring and marketing. One chapter deals specifically with seeds and plant-breeding, and in a short appendix the major pests and diseases are classified, market-containers catalogued, and a summary given of the principal fertilizers with which the grower is concerned. A task of this nature bristles with difficulties, but most of these have been overcome with commendable skill.

Mechanization, large-scale growing, linked with a certain amount of farming, and especially animal husbandry for production of farmyard manure, are what the writer visualizes in the future, in order to cut down costs, supply organic matter to the soil, and rest the land; he apparently holds out little hope for the small-holder. Hand-working everywhere must be cut down to

a minimum, and it is somewhat of a shock to find that commercial growers of spring-onions in Bedfordshire still practise hand-hoeing by "crawling" between the narrow rows.

Horticulturists and agriculturists are notoriously addicted to slackness of expression. For production of spring cabbage we are told that seed is sown in early autumn; July, the month of sowing, is surely summer! Again, "winter" cabbage are cut during the months of October, November and December!

In the table on page 49, the amounts of seed required for raising plants of cabbage and brussels sprouts are given as 4 – 6 oz. per acre; for the former, the rate is none too liberal and for the latter it is below the safety margin; the "ship" should not be spoilt for a ha'porth of tar.

Growers of asparagus, single row system, on the heavy Evesham soils (where horse-work is almost unknown) would not be in agreement with the suggested distances between the rows, viz., 4, 4½ or 5 feet; neither would they sow for each acre, to furnish a much greater number of plants, such a liberal allowance as 5 lb. of seed.

Methods of growing vegetables for market differ widely from county to county and, therefore, successful practice can never conform to uniform rules.

These criticisms are not intended to depreciate, even in any small measure, the efforts of the author and his useful publication. The book is illustrated with 36 excellently reproduced photographs. R. C. G.

The Pests of Fruits and Hops. By A. M. Massee, D.Sc., F.R.E.S. Pp. 265 + 26 plates. (Crosby Lockwood & Son, Ltd.) Price 15s.

The subject matter of this book is dealt with chapter by chapter according to the crops attacked, apple, cherry, etc. The apple, of necessity, takes up most space—about one third of the book. It may rather shock the grower to find 75 species listed as the most important pests found on the apple, but by means of asterisks he is relieved somewhat to find that 13 are the most important, against which measures must be taken.

The general treatment of each species is very good. There are some general notes; the recognition in the field, either the insect itself or the damage it does, or both; some notes on its life cycle and control measures. All these are apt to be interspersed with little "tips" of a practical kind that can only be given by one who knows his subject well. Perhaps it is a little unfortunate, however, when efforts are being made to standardize common names, that the larva of a beetle becomes a caterpillar a few pages further on.

The entomologist studies insects and must surely yield to their charms. The economic entomologist devotes his energies to devising means of destroying them, yet it is necessary to be the entomologist first. Can east meet west? This confliction of views appears on at least two occasions and rather adds to the merit of the work; one is the plea for "the lappet and many other beautiful insects," and the other the "life time memory" of the dropping of the Cherry Fruit Moth caterpillars.

We are all too familiar with the gibe that a scientific book must of necessity be dry of reading. It is surprising how only an odd word here and there may be necessary to sustain interest. The light traps "which sound rather exciting"; the emphatic "Now" on page 49; the capsid eggs easily "spotted," and the "most of them are of little value" control measures which haven't been quoted, are examples which brighten considerably the subject matter.

The author becomes contentious over the "time wasted on research into the control of a pest that has already been mastered." While the meaning is clear and there would be a broad general agreement with him, the whole basis of the statement may be refuted at any moment. The complete remedy is not necessarily the best remedy, nor need it remain so for all time.

There is a very good chapter on "Insecticides" and one by the well-known authority Mr. J. Turnbull on "Spraying Equipment and Methods." In the chapter on "Beneficial and Harmless Insects," the author has extended somewhat the list of species usually given. It is really difficult to know where to stop in this matter, but sufficient is given to let the grower know that there are no end of insects liable to be in the orchard, which are in no way pests.

The book is an extraordinarily good summary of our present knowledge and is a work urgently needed. Dr. Massee is to be congratulated upon producing at such a small cost, a book which will be of immense value to all who are concerned with the science or the practice of modern horticulture.

A. R.

Scientific Horticulture. (The Journal of the Horticultural Education Association), Vol. V, 1937. Price 3s. 6d. (postage 5d. extra). Obtainable from The Editor, South Eastern Agricultural College, Wye, Kent.

Although the bulk of this volume is concerned with specifically horticultural problems, there are several features likely to interest agriculturalists. Dr. T. Whitehead contributes an article on "The Virus Problem in relation to Seed Potato Production in North Wales" which, in conjunction with the late Dr. W. Maldwyn Davies's "Aphis Migration and Distribution in relation to Seed Potato Production," illustrates the difficulties of obtaining really "clean" commercial samples of seed potatoes. Chemists will appreciate the survey of "Some Recent American Work on the Copper Fungicides" by R. W. Marsh, "Peat and Its Uses in Horticulture" by Dr. W. G. Ogg and Professor G. W. Robinson's article on "Problems of Horticultural Soils." There is a useful account of "Plant Hormones and Their Possible Importance in Horticulture" by M. Thomas, whilst the article on "The Routine Management of Lawns" by R. B. Dawson should be useful to members of the A.E.A. who are also householders. There are fourteen pages of book reviews and lists of members of the H.E.A. and County Horticultural Officers in the United Kingdom and Irish Free State.

Milk and Nutrition. Part I, The Effect of Commercial Pasteurization on the Nutritive Value of Milk, as Determined by Laboratory Experiment. Issued from The National Institute for Research in Dairying (University of Reading) and The Rowett Research Institute, Bucksburn, Aberdeen. Price 2s. 6d. By post, 3s.

The Milk Nutrition Committee was set up at an informal conference called by the Milk Marketing Board's Advisory Committee on Milk Publicity towards the end of 1934, and is charged with the task of conducting investigations into the nutritive value of milk The Committee started with the

much-debated problem of the effect of pasteurization on the nutritive properties of milk, and the present report represents a first instalment of their efforts "to decide as precisely and unequivocally as possible" what this effect may be.

It was considered that properly designed experiments on small laboratory animals, where almost every factor could be adequately controlled, offered excellent prospects of clear-cut results, and should therefore be included in the scheme of work, which extended further to calf-rearing and the use of milk in schools.

The present report deals only with the laboratory experiments with rats, supplemented by direct chemical estimations of the vitamin potency of raw and pasteurised milk. The specific points investigated were the effects of commercial "holder" pasteurization on (*a*) the nutritional availability of calcium and phosphorus in the milk; (*b*) on the biological value of milk proteins; (*c*) on vitamin content, and (*d*) on the total nutritive value of the milk. The results are embodied in seven detailed reports.

Neither the availability of the calcium and phosphorus nor the digestibility and nutritive value of the proteins of the milk was found to be affected by the pasteurization. When used for rats as an exclusive diet, pasteurized milk supplemented with iron, copper and manganese (to ward off nutritional anæmia) was not inferior to raw milk supplemented in the same way. Neither the vitamin A itself nor the provitamin, carotene, was affected by heat-treatment, but there was some loss of vitamin B (probably mainly in the B_1 fraction), and also of vitamin C. The loss of vitamin C was assessed at about 20 per cent. of the original vitamin C content of the milk, but it is pointed out that factors other than pasteurisation may have contributed to this loss.

The discussion of the extent to which findings obtained with the rat as experimental animal are capable of application to the problems of human nutrition is deferred until the later report dealing with the investigations on calves and on school children, the issue of which will now be awaited with great interest. C. C.

BULLETINS AND REPRINTS

Agricultural Education authorities are invited to send copies of their publications to the Editor for inclusion in this section.

UNIVERSITY OF DURHAM — ARMSTRONG COLLEGE.

"An Agricultural Survey of the Northern Province. The Counties of Durham, Northumberland, Cumberland and Westmorland," by J. A. Hanley, A. L. Boyd and W. Williamson. 1936.

Large-scale coloured contour map of the Northern Province, comprising the counties of Northumberland, Durham, Cumberland and Westmorland.

SEALE-HAYNE AGRICULTURAL COLLEGE, NEWTON ABBOT, DEVON.

Department of Plant Pathology. Pamphlet No. 47 Thirteenth Annual Report for the year ending 30th Sept., 1936.

HERTFORDSHIRE COUNTY COUNCIL.

Institute of Agriculture, St. Albans.

"The Grassland of Hertfordshire and its Improvement," by H. W. Gardner. 1923–35, No. 450, Dec., 1936.

WILTSHIRE COUNTY COUNCIL.

Polebarn House, Trowbridge, Wilts.

Advisory Report on Milk Production.

This deals with Accredited and Tuberculin Tested Milk, Mechanical Milking, Diseases, Building Adaptations and Administration.

WORCESTERSHIRE COUNTY COUNCIL.

Department of Agricultural Education, County Buildings, Worcester.

Agricultural Quarterly Chronicle, Vol. V, No. 2, Feb., 1937; No. 3, May, 1937.

LINGNAN UNIVERSITY.

Canton, China.

Lingnan Science Journal, Vol. XVI, No. 1. (Issued 13th Jan., 1937.)

THE AGRICULTURAL COLLEGE OF SWEDEN, UPSALA.

Lantbrukshögskolans annaler. Annals of the Agricultural College of Sweden. Vol. III, Uppsala, 1936.

This volume contains, in addition to articles in Swedish, an article by N. Bergtsson on "The Decomposition of Cellulose, Pentosans and Lignin in Soil. Experiments on Barley Stubbles and Roots in Sand," with a summary in English; an article in English by Chr. Barthel on "A New Method of Differentiating Biochemically the *Coli* and *Aerogenes* Groups of Bacteria"; an article in English by Robert Torssell on the "Influence of External Factors on Seed Setting in Lucerne," covering 48 pages.

IMPERIAL BUREAU OF PLANT GENETICS.

School of Agriculture, Cambridge.

"The South American Potatoes and Their Breeding Value." (Price 3s. 6d.)

The exploitation by the Russian breeders of material gathered by their expeditions to South and Central America has given a great stimulus to potato breeding. In place of the one species of cultivated potato previously known over a dozen locally cultivated species have been found, together with over thirty wild species. The results of the work on this material have been published mainly in Russian, and the bulletin issued by the Imperial Bureau of Plant Genetics on "The South American Potatoes and Their Breeding Value" can therefore be considered as the first comprehensive account in English of one of the most remarkable discoveries that have ever been made in plant breeding. It deals with the collection of the material, its systematics and cytology, the origin and early history of the domestic potato and with certain specific applications of the new forms, such as their value in breeding for frost resistance and blight resistance, the use of the new species *Solanum andigenum* in breeding, and breeding for higher protein content or for short dormancy.

"The Experimental Production of Haploids and Polyploids." (Price 5s.)

Besides an extensive bibliography on the subject, the bulletin contains a concise account of the work already done and so forms a valuable guide to the available data. It is shown that the occurrence of haploid and polyploid cells in somatic tissues may be induced by such varied agencies as chemicals, X-rays, high and low temperatures, centrifuging, decapitation of the main stem, etc. From such cells there is always the possibility of the initiation of a new plant. The bibliography includes nearly 300 entries.

"An Outline of Cytological Technique for Plant Breeders. (Price 1s. 6d.) With a Foreword by Sir A. Daniel Hall.

A knowledge of cytology and some acquaintance with its technique has become essential to the plant breeder. The aim of this publication is to give an account of the standard methods used in plant cytology and it is based on practical experience with these methods rather than on a survey of the literature.

REPRINTS.

FENTON, E. WYLLIE: Biological Notes for 1936, *Scottish Journal Agric.*, Vol. XX, No. 1, Jan., 1937.

FRASER, G. K.: "An Example of Variation in the Rate of Free-Growth Resulting from Differences in the Soil," *J. Soc. of Foresters of Great Britain*, Vol. X, No. 2, 1936.

FRASER, H.: "Commercial Horticulture in Essex," *Scientific Horticulture*, Vol. V, 1937.

LING, A. W., and MUIR, W. R.: "The Effect of Poultry on the Chemical Composition of Herbage and Soil," *J. of the Min. of Agric.*, Vol. XLIII, No. 11, pp. 1056–67, Feb., 1937.

MITCHELL, R. L., and MUIR, ALEX: "Base Exchange Capacity and Clay Contents of Soils," *Nature*, Vol. CXXXIX, p. 552, 27th March, 1937.

OGG, W. G.: "Land Reclamation in Scotland," *Agric. Progress*, Vol. XIV (Part 1), 1937.

OGG, W. G.: "Peat and its uses in Horticulture," *Scientific Horticulture*, Vol. V, 1937.

SHEWAN, J. M.: "Analysis of Mineral Constituents in certain Forest Soils in North-East Scotland," *J. of the Soc. of Foresters of Great Britain*, Vol. X, No. 2, 1936.

STEWART, W. LYLE: "The Control of Sheep Ticks," *J.R.A.S.E.*, Vol. XCVII, 1936.

THOMAS, BRYNMOR: "The Composition and Feeding Value of Heather at Different Periods of the Year," *J. Min. of Agric.*, Vol. XLIII, No. 2, pp. 1050–55, Feb., 1937.

THOMAS, BRYNMOR, and BOYNS, B. M.: "The Composition of Grass Laid up for Winter Keep," *The Empire Journal of Exper Agric.*, Vol. IV, No 16, Oct., 1936.

THOMAS, EDGAR, and VILLIERS, F. H.: "Grassland Dairying in the Blackmore Vale," *J. of the British Dairy Farmers' Association*, Vol. XLIX.

WEBSTER, M. E., and ROBERTSON, IAN M.: "Permanganates and Plant Growth," *Nature*, Vol. CXXXIX, p. 71, 9th Jan., 1937.

NOTES

THE SUMMER CONFERENCE

The 1937 Summer Conference will take place at Oxford from July 24—27 inclusive. Committees will meet on July 24th and the Council on July 25th; the General Meeting will take place on July 26th.

Accommodation in College is not likely to be available on the night of Friday, July 23rd, for those *not* attending the Organizers' Conference.

FOURTH INTERNATIONAL GRASSLAND CONGRESS

The Volume of Abstracts of all papers to be read or presented at this Congress in Aberystwyth on July 15, 16 and 17, has just been published in both English and German (Aberystwyth, April, 1937). There are in all abstracts of 75 papers to be read by delegates coming to the Congress from all parts of the world. The full papers to be read at Aberystwyth together with the subsequent discussions will be published in a report of the Congress to be issued in the autumn. The Abstracts and complete Proceedings are available for £2 sterling, the Abstract Volume alone for 5/-. Copies may be obtained from the Joint Secretaries, Fourth International Grassland Congress, Aberystwyth, Great Britain.

AGRICULTURAL PROGRESS

VOL. XIV (Part III). 1937

AGRICULTURAL EDUCATION ASSOCIATION

The object of the Association is the development of agricultural education and research by mutual assistance and advice. It includes county agricultural organizers and instructors, and members of the teaching, research and advisory staffs of agricultural colleges, departments and research stations. The Association was established in 1894, and reconstituted in 1899. Its membership now is about 500.

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"... Pater ipse colendi
Haud facilem esse viam voluit . . "—VIRGIL

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AGRICULTURAL PROGRESS VOL. XIV (PART III)

CONTENTS

IN THE BEGINNING: A Series of Articles dealing with the Development of Agricultural Educational and Research Institutions.

3. EDINBURGH UNIVERSITY AND EDINBURGH COLLEGE OF AGRICULTURE

By E. Shearer, M.A.,

Principal of the College and University Professor of Agriculture

Edinburgh University can justly claim the distinction of having been pioneer in the domain of Agricultural Education, because her Chair of Agriculture was founded in 1790; and although funds were bequeathed the same year for the institution in Marischal College, Aberdeen, of "a Lectureship in Chemistry, Natural History and Agriculture," the first lecturer was not appointed till 1840; and, furthermore, as has been shown in a previous article in this Journal, the bequest made in 1796 for the endowment of the Sibthorpian Professorship of Rural Economy at Oxford also became effective only in 1840.

The Chair of Agriculture at Edinburgh was the first in that University to be founded by a private benefactor. About the middle of the eighteenth century, at the instance of Lord Kames, Dr. Cullen, Professor of Chemistry, had given some lectures on the Science of Agriculture, while in 1788 Dr. Walker, then Professor of Natural Philosophy, had given a more extended course on the same subject. It was probably these initial attempts at exposition of agricultural science which suggested to Sir William Pulteney the idea of presenting a Chair of Agriculture to his old *Alma mater*.

Having placed £1,250 in the hands of the Town Council, who gave him a bond for it at 4 per cent. interest, obliging themselves and successors to pay an annual salary of £50* to the Professor, on 7th July, 1790, Dr. Andrew Coventry of Shanwell, presented to the Senatus a commission appointing him to be Professor of Agriculture in the University. The Professor was bound to deliver "a set of Instructions or Lectures on the subject of Agriculture, respecting the nature of soils and manures; the modes of cultivation; the succession of crops; the construction of implements of husbandry; the best and most successful known practices; the manner of

* In a letter to Professor Adam Ferguson dated 21st March, 1789, Pulteney shows that he did not believe in pampering Professorial staff for he states: "I am not of Principal Robertson's opinion that it would be right to make the salary higher because our object is to make it an object to the Professor to exert himself very much and by no means to make this a sinecure."

instituting experiments to ascertain the effect of any proposed practice in any soil or climate; and the best manner of introducing or training skilful labourers and country artificers, where these may be wanting."

The presentation of this commission was remarkable for the number of protests it evoked. First, the College Bailie, *pro forma*, protested against the rights of the Town Council being prejudiced by a private individual having founded a Chair. Secondly, the Professor of Natural History protested that the new Chair was not to hinder him from teaching "any branch of Natural Science." Thirdly, the Professor of Botany protested that the Professor of Natural History could not claim the right of teaching botany. And fourthly, the new Professor protested against any one but himself giving "a separate course of Georgical lectures." Which protests having been duly registered, the Chair was inaugurated and proved to be no source of discord within the University. It was occupied by Dr. Coventry for forty-one years. Evidence given by him before the Royal Commission of 1826 showed that up to that time he had delivered thirty-two courses, some of them consisting of more than one hundred and forty lectures. His classes, ranging in number of students from thirty to seventy-eight, were attended by the sons of practical farmers, writers who had the management of estates, divinity students and others. He was recognized as an authority on agriculture in Scotland, and frequently gave evidence before committees of the House of Commons. The drainage of Loch Leven and the reclamation of surrounding lands were carried out under his direction. He was the author of two small treatises on "The Succession of Crops and Valuation of Soils," and on "Dairy Produce."

His successor, David Low (1831–54), who had previously been editor of *The Quarterly Journal of Agriculture*, took early steps to urge upon the Board of Manufactures, and then upon the Government, the necessity for forming an Agricultural Museum in Edinburgh: in 1833 the Chancellor of the Exchequer made available a grant of £300 a year for this purpose. Low contributed collections of his own and employed an artist (Mr. Sheils, R.S.A.), to travel throughout the kingdom and portray superior specimens of the different breeds of live stock. The products of his brush—a hundred paintings—hang in the existing University Department of Agriculture—a historically interesting, if from their vast superficies a somewhat embarrassing collection. Altogether £3,000 was expended on the Museum, of which half came from Government. The establishment of the Museum apparently stimulated attendance on the class of

agriculture, which numbered from seventy to ninety students during the earlier years of Low's tenure of the Chair. His published works included the *Elements of Practical Agriculture*, which was translated into French and German, *The Breeds of Domesticated Animals of the British Islands*, with coloured plates (two vols, 4to, price £16 16s.) translated for the French Government, and *Landed Property and the Economy of Estates*. He was corresponding member of most of the great agricultural societies or academies on the Continent.

John Wilson (1854–85), the next occupant of the Chair, was a recognized authority on British Agriculture, and is best known as the author of *Farm Crops*, long a standard work.

From the foundation of the Chair of Agriculture in 1790, no further provision was made for agricultural teaching at the University for a century. Agricultural students could, and frequently did, take the ordinary classes in subjects such as botany, chemistry, natural history and economics, but there were no courses relating these sciences to the practice of agriculture.

Professor Robert Wallace, who succeeded Professor John Wilson in 1885, set himself to remedy this defect. In 1890, largely through his efforts, an endowment was obtained for the Steven Lectureship in Agriculture, which has been devoted to the provision of a course in Agricultural and Forest Zoology. In 1892 he co-operated with a number of extra-academical teachers in forming the Edinburgh Incorporated School of Agriculture, which offered courses in the principal branches of agricultural science.

The avowed object of the formation of the Incorporated School of Agriculture was to establish a body to whom Government grants could be made payable, and it was so far successful in its purpose that the English Board of Agriculture gave official recognition to Edinburgh as an agricultural teaching centre. A fundamental part of the policy of the Board, however, was to encourage the development of teaching centres which would serve wide areas and be responsible for the organization and co-ordination of agricultural instruction of all grades within these areas, and which would secure the co-operation of County Authorities who had funds at their disposal for promoting technical education. The Board, therefore, while continuing to make grants to the University, suggested that the University Court should consult with the Highland and Agricultural Society regarding the consolidation of the agencies in Edinburgh engaged in the teaching of agriculture and kindred subjects; and further, that the co-operation of local authorities be invited with a view to the establishment of a centre for systematic

agricultural study, for the training of agricultural teachers and for the organization of extension work.

Action by the University on these lines resulted in the setting up, in 1895, of a teaching organization known as the Edinburgh School of Rural Economy, which made provision for a two-year curriculum for day students, for a considerable evening class programme and for a limited amount of extension work in agricultural instruction.

In 1901 a conference, which included representatives from the University, the Town Council of Edinburgh, the Highland and Agricultural Society, the Edinburgh School of Rural Economy and the County Councils, agreed on a scheme of agricultural education and research, embracing a central college at Edinburgh and extension teaching in the associated counties. Hence, in July, 1901, there came into being the Edinburgh and East of Scotland College of Agriculture, in which was merged the Edinburgh School of Rural Economy.

The College of Agriculture is administered by a Board of Governors representative of Local Authorities, of the University and of various other interests. It exercises functions which, in the main, are distinct from those of the University Department of Agriculture. It makes provision for central instruction of a standard definitely lower than that given at the University while, perhaps, its most important function, and that which operated as the principal motive in its formation, is its programme of Extension Agricultural Education. The two, however, work in close liaison, and the establishment of the College has made good various deficiencies which existed in the University provision for agricultural education. Thus, the College has developed departments of agricultural chemistry, agricultural bacteriology, agricultural engineering and veterinary hygiene, which provide graduate courses for University students; while on the College experimental farm are found facilities for the practical instruction of University students and for the conduct of research by the University staff. The assistance rendered by the College in these directions has enabled the University to concentrate on strengthening those departments of agricultural study for which it is directly responsible.

In 1888 the University instituted the Degree of Bachelor of Science in Agriculture, the first to take the degree being the late Sir William Somerville, afterwards Sibthorpian Professor of Rural Economy in the University of Oxford.

The increase in the number of students and the development of teaching which took place in the early years of the present century

having rendered wholly inadequate the accommodation of the department of agriculture in the old College, the University acquired a site at No. 10, George Square in immediate contiguity to the College of Agriculture, on which was erected in 1914 the building which now houses the Departments of Agriculture and Forestry.

The regulations governing graduation in agriculture were amended in 1922. The subjects of study prescribed for the Ordinary Degree of Bachelor of Science in Agriculture underwent substantial modification, and Honours Degrees in one or other of the Departments of Agricultural Science were instituted for the first time.

Professor Wallace, whose tenure of the Chair had been associated with a notable development in his own department and in the general provision for agricultural education at the University, retired in 1922 and was succeeded by Professor James A. Scott Watson. When the latter, in turn, resigned at the end of 1925 on his appointment to the Chair of Rural Economy at the University of Oxford, the University Court and the Governors of the College of Agriculture, with the avowed object of achieving a more intimate relationship between the University and College, entered into an agreement for the appointment of the Principal of the College as University Professor of Agriculture.

AGRICULTURAL EDUCATION IN THE COUNTIES

(a) The Farm Institute*

BY J. HUNTER SMITH, M.C.,

Principal, Hertfordshire Institute of Agriculture

The special function of a farm institute is to provide practical and technical training for young people seeking a career on the land It is this concentration on one objective that gives the institutes their strength and makes them strongholds of educational endeavour.

But strongholds without supplies are of little value, and the supplies that matter to farm institutes are suitable students. An organized system of rural education might be expected to bring forward hosts of candidates from whom each institute would select the required quota, just as is done with free places for secondary schools. The lack of adequate competition for institute training is a factor in the situation which cannot be overlooked; it tends to make the institutes isolated strongholds which have to forage as best they can for the annual replenishment of their stocks—a dangerous and yet an invigorating position.

For the time being the success of existing and new institutes must depend on central organization to avoid overlapping. One example of overlapping was occasioned in the early days of the Hertfordshire Institute by providing a large dairy for giving instruction in butter and cheese making in a county where butter and cheese are never made. That dairy has now been replaced by a small all-electric dairy where milk can be handled in a modern way, and manufacture is confined to such products as cream cheese, ice cream, etc. The cost of the original mistake and correcting it amounted to many hundreds of pounds. Another possible error which I trust will not be made would result from the replication of our glass house department at all other institutes.

The point I want to make is that each institute, in addition to sufficient diversity to meet local requirements, should have one or two specialities which would attract students from other counties and be managed strictly on economic lines. Our glasshouse nursery is one, fruit might be another, mechanization with all that is involved another, butter and cheese making another, a smallholding another,

* Substance of an address given at Oxford, July, 1937.

and so on. Institute farms might vary in size from a thousand or more acres where complete mechanization is the main feature, down to fifty acres or less where the aim is the training of small-holders.

The number of students will vary greatly, mainly in proportion to the facilities for practical training. That at least has been the line of development in Hertfordshire. In the early years our establishment ranged from twenty to thirty students, and now having developed facilities in a number of directions we are thinking in terms of sixty to eighty. Progress is of course determined by success in timing each venture to miss periodic cyclones of economy, to avoid contrary currents of opposition, and to catch the gentle winds that favour development.

At a farm institute I maintain it is not necessary to confine entries to farmers' sons or even to young people of rural origin. Many candidates come from urban areas. Some of these are first-class lads who have had a good education and who are determined to seek a career in the country, at home or abroad. My initial reception of these young people is always discouraging; I paint the blackest possible picture of future prospects and insist on at least a year being spent on a farm before taking a course at an institute. Others are young men who, after a few years in business, are determined to give it up in favour of the country, even if this involves manual work and a lower income. Occasionally also one can render services to older men seeking some healthy out-of-door activity to provide interest and perhaps a modest income.

All of these recruits to agriculture should be welcomed; they bring new blood, brains and capital to the industry, and there is no more useful function of a farm institute than to befriend people who would otherwise drift aimlessly into the country with correspondingly reduced chances of establishing themselves in their new environment. Unfortunately this initial reception is not followed up by organized schemes of land settlement such as exist abroad.

Now the farm and other commercial departments at an institute have many functions. In the briefest terms they help the staff to practise what they preach—a most salutary limitation; they provide students with opportunities for practical work, of which more anon; they bring farmers and practitioners to the Institute to discuss problems, trials and demonstrations; finally, they afford opportunities to interest children from urban schools, and townspeople, rotary clubs, trade unions, women's guilds, etc., etc., in the countryside.

A farm institute is not a miniature agricultural college, the main distinctions are adherence to a course not usually exceeding one year in duration, and the time allotted to practical work. Practical work is invaluable, provided it is combined with systematic instruction and equally systematic discussion to ensure that each student acquires the habit of making correct observations. Nothing can be taken for granted; it is necessary to begin with the simplest things and to progress stage by stage to the more complex.

For training in manual operations, for developing powers of observation, and for technical illustration of lectures, commercial departments and field and stock trials and contrasts are indispensable. But the most difficult problem is to round off and elaborate these aids into a systematic if elementary study of farm management. This involves continually presenting students with the reason for day-to-day decisions, with questions of policy on labour organization, and allowing free access to records, accounts, etc. There must be no secrets, as failures are often more instructive than successes. The art and technique of farm management is still largely a closed book, and it will remain closed till the higher centres of agricultural education take up the challenge and train at least a proportion of their men in the technique of manual processes, the psychology of farm labour, *landarbeitslehre*, and the art of teaching.

Regarding the future of students, it must suffice to say that most of them are likely to succeed in their subsequent careers proportionately as they recognize that for some years at least they must earn their livelihood by the sweat of their brows, that skill in handicrafts is the first essential, and that a sustained desire to learn and keep on learning is the proper spirit. If the capacity to observe and think, and to apply observations and thoughts to particular circumstances in a constructive way has been developed, these qualities will be better allies than stored information and much learning.

To the above reference to colleges may I add these points. First, full recognition of the training at farm institutes as a contribution towards a diploma is an elementary right conceded only by the examining board of the Royal Horticultural Society for the N.D.H. I do not want to raise a discussion on this subject, but I do suggest that the regulations for the diploma mentioned are infinitely more sound and give far more encouragement to those taking up horticulture as a career than those of the other three diplomas.

My second point arises from the first, as, in my opinion, diplomas should be given to men with a general knowledge of a subject combined with highly specialized practical and technical training

in a specific branch of that subject. Current diplomas underrate the complexity of agriculture and do a dis-service to the men who receive them. Perhaps one day the N.D.A., with management as the special subject, will be a certificate of actual managerial ability, and thus solve an acute problem in the selection of bailiffs, farm managers, and much-needed instructors in manual processes. To mention one other point, of which I can speak from personal experience, the effectiveness of the work which I have had to undertake would have been greatly increased had I received at college some initial training in the art of teaching (and for that matter in the art of writing papers for conferences).

One other suggestion might be made regarding smaller farm institutes in rural area. Would not the circumstances in these cases lend themselves to the establishment of a rural secondary school in association with the institute? This however raises many considerations which it is impossible to discuss in this paper, and I therefore merely mention it in passing without further comment.

I often feel that the Ministry of Agriculture would render a useful service by collecting the prospectuses, annual reports and accounts of each farm institute and circulating a summary with observations on special features, developments, etc. At present we know very little about each other and have no means of comparing notes unless we devote a holiday to a round of visits. For example, with one exception, I have not visited a sister institute for many years, and some of them I have never seen. On behalf of the farm institutes, may I say that we would welcome more visits by members of the staffs of other institutes and by professors and lecturers on college staffs along with their students. May I therefore extend to one and all a cordial invitation from the Hertfordshire Institute.

Incidentally an exchange of staffs between colleges and institutes for short or long periods might be a means of encouraging co-operation and help all concerned to visualise differences in function and outlook.

Reference may also be made to another matter. A ladder of progress in general education has been mentioned—should there not be a similar ladder for those engaged in agricultural education? This might be farm employment to farm institute, to diploma or degree course, to county work back to farm institute, and then to college, university or administrative post. But this round of progress apparently does not work in practice, first because as a training centre the existence of farm institutes is totally ignored

by educational bodies, except in the case of horticulture, while, if I am not mistaken, some of the best posts exist in the counties. It might be advantageous to introduce the equivalent of a Burnham Scale along with the system of regulated transfer in suitable cases.

(b) The Experimental Farm*

By A. W. Oldershaw, M.B.E.

Agricultural Organizer for East Suffolk

First of all, I think it is very important to confine the experimental work to specific points, and after one is sure of the ground, to proceed to demonstrate them in as clear a manner as possible.

I do not think any clear line is desirable or possible between experimental and demonstration farms. One may very likely have to try out some system of farming locally, and then, if it proves successful, to demonstrate it by continuing the work for a number of years. This has been the case at both the Experimental Stations with which I have been associated. These I will briefly describe.

In the year 1899 the Chairman of the Agricultural Education Committee was asked to report on the best means the County Council could adopt of benefiting agriculture. He paid a visit to Rothamsted, and, as a result, recommended the establishment of a small Field Experimental Station.

The plots at Saxmundham were forthwith started, with a view to studying the problems of poor heavy land, of which there is a large area in the county. Two fields with a total area of about 20 acres were taken. One of them was almost derelict grassland; the other was arable land just on the borderland of cultivation. The work was planned by Professor (afterwards Sir William) Somerville (at that time Professor of Agriculture at Cambridge), Mr. A. Harwood (Chairman of the Committee) and Mr. H. Fiske. Subsequently Professor (now Sir Thomas) Middleton, who followed Professor Somerville at Cambridge, took a great interest in the work, as did also other members of the Cambridge staff.

In the arable field two rotations were started. In both of these the four-course rotation was adopted. In Rotation 1 each of ten plots receives the same manure annually, no matter what the crop. In Rotation 2 the crops receive varying manuring. Both these rotations are still in being.

* Substance of an address given at Oxford, July, 1937.

The grass field was partly devoted to sheep grazing tests (in imitation of Cockle Park), partly to seeds mixtures, and partly to manurial tests on the semi-derelict grass. Most of these have been modified in various ways since the commencement.

The specific points demonstrated are:—

(1) The great value of phosphates on both arable and grass land of the type selected.

(2) The high level of productivity which can be obtained if the semi-derelict grass land is broken up, re-seeded and suitably manured.

Tunstall experiments were started in October, 1925. About twenty acres of almost derelict light land were taken over. One of the fields had not grown a satisfactory crop for three years. On the whole, these two fields were typical of at least 100,000 acres in the county. Sir J. Russell, the Rothamsted and the Cambridge University Staffs have helped materially with advice.

Shortage of lime was suspected, and an analysis of the soil showed this to be the case. Chalk was available at a distance of twenty miles, but local tradition said that less than ten or twelve tons per acre was useless. It was available at 8s. per ton delivered on the field. By spreading on the land in autumn and allowing the weather to break it down before ploughing in, it has been shown that five tons per acre are sufficient to last for at least ten years. An initial expenditure of 50s. per acre, including spreading, resulted in the first ten years in extra crops worth £64 on the chalked half of the field, after deducting the cost of the chalk.

It has been found possible to grow lucerne and sainfoin on this light blow-away sand after chalking. After seven years of lucerne, broken up in 1935, twenty tons per acre of sugar beet were grown in 1936.

For many years it has been the custom to hold an annual inspection at Saxmundham. Usually some well known authority on agriculture is invited to lecture in the barn. At Tunstall several inspections are held during the summer.

Both Stations are of great value to the district, since they provide ocular demonstration of the points in question. They enable the County Staff to speak from personal knowledge on the problems in question, and to quote local figures in support of their statements. As they are under the control of the Organizer, he is responsible for seeing that the tillage operations are conducted properly. They undoubtedly greatly influence local farming—thus, partly no doubt owing to the influence of Tunstall, 60,000 tons

of sugar beet lime sludge were used during the past five years from the Ipswich factory, whilst from a single chalk quarry 40,000 tons of chalk were used in the same period.

I certainly think that in any district in which specific problems require investigation or demonstration, small stations of the type indicated, which are under the direct control of the County Staff, are of the greatest possible value.

(c) The Experimental Plot*

By J. W. Dallas,
Agricultural Organizer for Bedfordshire

I interpret the meaning of a County Experimental Plot to be a number of plots allowing of experimentations by a suitable replication of treatments at any one centre, a centre to be a place other than the County Experimental or Demonstrational Farm, and the duration of the work of one season or more. County Experimental Plots mean a series of centres, temporary or permanent, where work of exactitude is carried out mainly for local information. I do not propose to refer to what are known as Demonstration or Observation Plots except to say that Experimental Plots can be used for demonstrational and for observational purposes, whereas Demonstration or Observation Plots involving scanty or no repetition of treatments are less trustworthy, and accordingly of very limited service to us.

The Report by this Association on "The Organization of Systematic Courses of Instruction" begins:—"Agricultural Education must become part of the normal education system of every rural area. . . . County schemes should, therefore, begin with the elementary school. . . . The teaching of this (rural) science might with advantage be correlated with School gardening. . . ."

I contend that the school garden can be made to fulfil a more definite purpose than hitherto in the teaching of science, particularly if modern experimental technique is adopted in the laying out of plots for treatments devised to provide good data for teaching purposes.

In 1931 I resolved to establish, with the consent of the Director of Education and the Head Teachers concerned, a definite scheme of manurial experiments and a suitable rotation of crops at elementary

* Address given at Oxford, July, 1937.

schools where ground space and circumstances permitted of a replication of treatments in a manner conforming to the requirements of the statistician. At that time the Education Committee was embarking upon a policy of erecting new senior, central or area schools with large gardens. As a result of experience gained, it is now an accepted principle in Bedfordshire that the main feature of a garden at a senior school should be a layout of three Latin squares of sixteen plots each, to permit of four manurial treatments being carried out—sixteen plots receiving the necessary dressings each year in a three-year rotation. Thus, there are forty-eight plots each of about two poles in area, devoted to what may properly be regarded by the teacher and the scholars as critical experimental work, with a definite aim to provide crop-weight data and observations upon the responsiveness of crops to particular treatments under their immediately local conditions. The necessary figures for statistical analysis are forwarded by the Head Teacher to me for submission to the Advisory Chemist of the Province, who reports upon their significance or otherwise. It is only then that the results are used for teaching purposes.

I was tempted to try the experiment of regularizing school gardening, as from observation it appeared that the teaching of school gardening required directing upon an objective. To me it seemed to be a form of instruction made up of some craftsmanship, and little science; much depended upon chance as to what resulted from the instruction or work carried out. I formed the opinion that a teacher, as a result of his training, was more likely to be successful in teaching scientific principles than in initiating his scholars into the subtleties of the craft. Furthermore, in rural areas at any rate, a boy was more likely to be taught proficiency in the craft by his father, but it would seem wise to get him definitely interested in science and develop a critical outlook at school.

The improved technique in the carrying out of the work, the contact with the Agricultural Education staff and the linkage with the Provincial Advisory Chemist are all to the good. The results of treatments are generally in accord with those of similar treatments carried out on adjoining farms under the county scheme of experimentation. The reduction of crops to those which are most useful and which do not require much attention during the summer holidays, and the limiting of manurial treatments means that what is attempted is well done. Teachers, too, realize that their work is now more trustworthy. I am satisfied that the school garden, if organized and in the hands of an interested teacher, can be regarded as a subsidiary form of a county experimental plot.

I perhaps ought to add that about one acre of land is provided for the practical garden at most of the senior schools so that, exclusive of the plots, there is space remaining for the growing of some trees, bush and soft fruits, and for seed beds and propagation work. Then there is what might be termed the pleasure garden in the immediate surroundings of the buildings, and here lawns and flower borders and named bushes, shrubs and trees, provide a good setting and material for developing enthusiasm for cultural and botanical studies.

It will be appreciated that schools with gardens in which the science of crop husbandry is a dominant feature and where the grounds contain material for nature study generally, provide suitable centres for continuation classes for the ages of 14 to 16 years. But the appropriate teachers are practically non-existent at present. There must, unfortunately, be a hold-up in progress until the training colleges regard rural sciences more seriously, or until persons trained at farm institutes or agricultural colleges are prepared to qualify themselves as teachers under the Board of Education regulations.

We all recognize how necessary local knowledge and experience are in our lecturing and advisory work. We are conscious of the progress that is being made in the industry and of the increased efficiency of the farmer and the grower. We know that agriculturists in the wide sense of the word are becoming more critically minded and discerning. Therefore, rigid test must precede demonstrations. Our experimental work must be continuous. We must by it not only feel the pulse of the present day but by it too, we must endeavour to be ready to advise on possible developments. It is less easy these days to demonstrate the value of mineral fertilizers than it was a decade ago. It is no longer easy to find crop varieties which are a striking improvement over those now in common use. The research stations and advisory centres are unable themselves to carry out all the critical work. For these reasons, county agricultural education staffs must participate in more exacting forms of experimentation than have been necessary in the past. County experimental plots must, particularly if no county farm exists, have a real place in agricultural education.

There exists a tendency for new theories to reach the farmer before they have been tested out under the conditions prevailing in a county or in differing districts of a county. Some of the tests, too, are not exact enough for present day requirements and our work is not as effective as it might be were the period of duration of experimental work extended. There is a paucity of information,

for instance, on residual values and on accumulative effects. The attention of the farmer has been focussed on artificial fertilizers because much attention of one season's duration has been devoted to such forms of plant food. Spectacular results have received undue publicity.

Direct or first year effects are not always what are wanted by the farmer. Chance must be eliminated as much as possible. Modern technique in the laying out of plots and the work of the soil chemist help greatly in this latter respect, and as a result there is increasing confidence in, and respect for, agricultural science when both are combined. The link with the advisory chemist is a valuable one in all our manurial experiments.

Perhaps it would be as well if the procedure I have adopted during the past seven years were outlined. In doing so, let me make it clear that there is no county demonstration farm in Bedfordshire, and that there was a break in agricultural education activities of about seventeen years until 1930. I am conscious that similar work by way of county plots and methods is being carried out elsewhere.

During the past seven years about one hundred soil samples per annum have been submitted to the Advisory Chemist of the Province; and in the past six years, with his help, experiments designed to give sound information on the responsiveness of various crops to different manurial treatments in several classes of soil, have been carried out. It was evident early on that with some treatments and under certain conditions it was not possible to get what are termed significant differences in one year. Accordingly in 1934, six centres were chosen where treatments could be carried out from year to year on arable crops in rotation, to test the accumulative effects of persistence in certain forms of treatment and to obtain insight into residual effects also. Each centre consists of an acre of land and the soil type and conditions were chosen having due regard to the locality and the nature of the problems to be investigated. One had to arrange with a farmer or grower in each of the districts to carry out the necessary work, but no difficulty was experienced in finding persons willing to undertake the somewhat involved duties. Thus were started what may be termed Permanent Experimental Plots. In point of fact, the duration of the work at any one centre is not likely to be more than ten years, so perhaps "semi-permanent" would be a better definition. The establishment of these centres has not meant the cessation of experimental work of say of one year's duration, and experiments having a linkage with other counties through the Provincial Conference in particular

have been continued. In all, about 120 manurial experiments have been carried out during the past six years; close on 700 main and sub-treatments, involving approximately 3,000 plots, have been tested out. The county experimental plots, and particularly those of relatively long duration, are furnishing information of high value in advisory work. I hope, too, that the teaching profession may augment their knowledge from this form of local work and so attain an outlook which will be helpful when circumstances permit of agricultural education becoming part of the normal education system in every rural area.

Apart, however, from the manurial and cultivation experiments which may be undertaken by groups of counties through the Provincial Conference, attention should be paid to the wider schemes of such bodies as the National Institute of Agricultural Botany. There may also be a quickening of interest in county experimental plots when effect is given to the clause (*h*) in paragraph 3 of Part 1 of the Agriculture Bill now being considered by Parliament. Here, under a supplementary provision of the Land Fertility Scheme, the Scheme may "provide for the making of arrangements for promoting research, investigation and instruction as to the use of lime and of basic slag as a means of promoting the fertility of the soil. . . ." This Association stimulated interest in field experimentation in the early days of agricultural education, and it might be opportune now for it to consider giving general attention to the matter of county experimental plots.

THE AGRICULTURE OF OXFORDSHIRE*

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SOILS

While the organization of farming varies from time to time with economic conditions, the natural environment remains a permanent endowment subject only to almost imperceptible change. Oxfordshire has not been particularly well endowed in the matter of soil or climate. It has none of the fine Leicestershire pastures, which fatten a bullock and a sheep to the acre in a grazing season; it has none of the rich fertile alluvial soils of the fens; nor has it that moist equable climate, which, as in parts of the west and north-west of England, may be relied upon to produce its daily quota of fresh and highly nutritious herbage to save farmers many anxious moments in regard to the supply of food, and much expense in the way of cake bills. For the most part the soils of Oxfordshire are poor in natural fertility, very thin and stony. For the most part, too, the county is hilly and undulating, and on this account cultivation is expensive and good grass is difficult to get. These facts, coupled with only a moderate rainfall of some 26 inches per annum, do not permit of high farming or high productivity.

Arthur Young in his survey of Oxfordshire over 100 years ago divided the soils of the county into four groups:—(1) the red soils, (2) the stone brash, (3) the chalk and (4) the area of miscellaneous loams. The red soils overlying the lias formation are found only in the north of the county around Banbury. Where the contour is flat the soil is a good, easy working two-horse loam chiefly in arable cultivation, but most of the red land area is hilly, and the inevitable grass and the almost inevitable dairy cow take the place of the plough. The farms average between 200 and 300 acres in size.

The north-west of the county is Cotswold country. Everybody, whether a lover of nature or not, whether townsman or country bred, admires this stretch of rolling hill country with its brown plough-land, its characteristic stone-built villages and stone walls in place of hedges. Here the farms are large, averaging between 300 and 400 acres with from 60 to 80 per cent. of the land in arable

* Paper read at Oxford, July, 1937.

cultivation. The soil is light and very stony, never of any great depth; it is difficult to handle in the spring and liable to dry out in drought. The corn brash, which is a thin belt lying to the south of the oolite, gives rise to a rather better, deeper and less stony soil and the topography is less undulating. In the nineteenth and early part of this century all of this area was sheep and corn land. As a variable soil did not always make it possible to get good samples of barley the preference was for wheat.

The chalk of Oxfordshire—the Chilterns—occupies the extreme southern end of the county. It is different from the chalk country elsewhere as there is little down. For the most part the soil on the upper chalk is overlaid by a flinty plateau gravel or clay with flints, and instead of the waterless, treeless downs, the Chilterns are covered with beech woods, which give rise to an important industry in this part of the county, or on the clay with flints with moderately good grassland which is used for dairy farming. This area, too, has recently become residential for London business men. The lower chalk, as in most other chalk areas, is in arable cultivation, with about 60 per cent. of the land under the plough. Barley is an important crop and some of the best malting samples in the country have been grown on this land. The farms again are large, and average about 200 to 300 acres.

South of the corn brash extending from Bampton in the south-west to Bicester in the east there is a narrow belt of Oxford clay, and north of the chalk there is another belt of gault clay stretching from Dorchester to Thame. In both of these areas farms are largely, and in many cases entirely, in grass. Milk production is the chief farming enterprise. The average size of farm is about 150 acres.

The remainder of the county consists of a variety of alluvium, gravels and sand. This area lies to the east and south of the city of Oxford, and also takes in most of the valleys of the Thames, the Cherwell and the Thame. From the agricultural point of view four main types of soil may be distinguished in the area of miscellaneous loams. Firstly, there is the alluvium of the river valleys. This is generally a black, rather heavy soil, and usually grows only poor grass. A good example of this soil is that of Port Meadow near Oxford. The alluvium in the valleys of the Cherwell and the Thame is, however, considerably more productive than that of the Thames, and the meadows of the Thame in the neighbourhood of Waterstock and Waterperry are accounted some of the best in the district. One great drawback of all this alluvial land, however, is that it suffers very frequently from flooding. The second main type of soil is the valley gravel, found principally in three areas.

In the Thames valley north of Oxford the gravel lies in well marked terraces and it is here that most of the arable land in this district is found. This belt of gravel soil is found between Eynsham and Bampton. South of Oxford, near Clifton Hampden, the soil is also gravel and again gives rise to a relatively high arable acreage. Is is on the whole a deeper soil, and less liable to suffer in time of drought, and good yields of most crops can be obtained.

The soil in the remainder and mainly the higher lying parts of the area of miscellaneous loams is generally sandy. Between Elsfield and Holton, and at Sandford and Iffley, the soil consists of coarse sands. This land is easily worked, but like most light soils suffers from dry seasons. Near Oxford it is used for market gardening. The soil on the hills between Garsington, Cuddesdon and Shotover is also mainly sandy. Near Culham, Nuneham Courtenay and Clifton Hampden a more productive sandy loam is found resting on the lower greensand. This soil is much less liable to burn and gives good crops. Potatoes were at one time extensively grown on this land, and the proportion under the plough is as high as anywhere in the area of miscellaneous loams.

Changes in the Area of Crops and Numbers of Livestock.

I do not wish to weary you with too many statistics, but I must give you a few in order to provide a background to the characteristics of the farming in the county and to the changes which have taken place during the last twenty years or so. Before the War, taking as the base the average of the years 1911–13, there were 411,544 acres of crops and grass in the county. The area has shown a continuous decline ever since, and in 1935 it was only 389,735 acres, a fall of 5·4 per cent. in some twenty-five years. The fall of 23,000 acres measures the encroachment of rough grazings and non-agricultural activities on the cultivated area. The latter is due principally to the withdrawal of land for the making of new roads, housing estates and industrial buildings. It is not possible to state the loss in this way between 1911–13 and 1921, but in the period of 14 years from 1921 to 1935, when housing and industrial development took place at a faster tempo, the loss of agricultural land in the county averaged about 800 acres per annum. The city of Oxford, with its new motor industry, has probably made the greatest individual inroad on the agricultural area, but on the Oxfordshire side of the Thames at Reading, around Banbury, and in fact in many of the small towns and villages, there is some new housing scheme or other development to provide further evidence, if that were needed, that industry and commerce take precedence

over farming, and of the shifting balance between agriculture and industry in this country. Thinking of it merely in terms of arithmetic, it may be calculated that if the loss of land to agriculture in the county proceeded at the same rate as in the past 14 years there would be no agriculture left in Oxfordshire in 500 years time.

TABLE I.

OXFORDSHIRE—AREA IN CROPS AND GRASS; JUNE 4TH

	1911–13 acres	1921 acres	1926 acres	1933 acres	1935 acres
Total acreage under crops and grass ..	411,544	406,886	397,837	390,930	389,736
Arable land	201,483	202,505	178,054	145,511	150,284
Permanent grass ..	210,062	204,381	219,783	245,419	239,452
Wheat..	40,739	44,933	38,335	40,115	43,195
Barley or bere ..	35,314	33,992	24,039	14,450	13,853
Oats	31,224	32,963	28,677	23,468	23,319
Rye	545	484	251	134	92
Beans	6,927	5,850	4,140	2,637	3,751
Peas	3,204	1,993	887	941	767
Potatoes	2,716	4,039	2,134	2,520	1,847
Turnips and swedes ..	20,944	13,671	11,234	8,495	7,607
Mangolds	6,601	5,484	4,666	3,542	3,633
Cabbage	501	823	1,956 (Cabbage, Kohl-rabi and Rape)	1,692	3,298
Kohl-rabi	98	66			
Rape	556	700			
Vetches or tares ..	4,301	2,962	2,653	1,119	1,114
Lucerne	1,553	1,417	920	837	864
Hops	—	—	—	—	—
Small fruit	228	203	105	72	87
Clover, sanfoin and grass under rotation	38,857	37,953	39,557	38,403	36,763
Other crops	785	1,331	1,241	1,164	1,287
Bare fallow	6,389	12,848	14,021	12,467	6,970
Mixed corn	—	793	793	372	280
Sugar beet	—	—	1,196	731	570
Orchards	—	—	1,306	1,054	1,038

The statistical picture of the agriculture of the county in the last twenty years indicates the violent nature of the adjustments which had to be made. In 1921 the arable area (about half of the total area of crops and grass) was much the same as in 1911–13, but in 1935 it had fallen by no less than 28·2 per cent. During the same period the area under permanent pasture increased by 20 per cent.* The proportion of arable is now rather less than 40 per cent.

* It may be noted, however, that the arable area increased and the grass area declined between 1933 and 1935.

of the total. Apart from wheat, of which as the result of the Wheat Act there was a larger acreage in 1935 than in the pre-war period, and temporary grass, in which the acreage has been fairly well maintained, the acreage of all the chief arable crops has fallen severely. Particularly has this been so in the case of barley, turnips and swedes, vetches and to a lesser degree of oats. Between 1911–13 and 1935 the acreage of barley dropped by about 60 per cent., the area of turnips and swedes by 63 per cent. and the area of vetches and tares by 75 per cent. These facts are a striking illustration of the great decline in the importance of the sheep fold, the fat teg and the yard bullock in the farming of the county, as well as of the cheapness of imported feed, as it became unprofitable to grow barley, most of which was only of value for feeding. The acreage of oats, a crop which is of importance in most of the higher parts of the county, fell much less steeply.

Oxfordshire has never been a great potato growing county. It is true that considerable acreages were grown in the area of miscellaneous loams, on the red soils near Banbury and on the corn brash at Stonesfield, near Woodstock. The quality of the potatoes grown, particularly on the corn brash, was always very good, but many of the soils are too thin to yield well even with an extravagant expenditure on farmyard manure and artificial fertilizers. The farmyard manure is no longer available, casual labour is difficult to find, while the riddle regulations of the Potato Marketing Board have been detrimental to Oxfordshire potatoes. The result is that the potato acreage in the county in 1935 has declined by almost one-third since pre-war days and by half since 1921, and at present the feature of potato growing is that most of the big growers have disappeared and the crop is grown in comparatively small acreages over the county.

Mangolds have also declined sharply and there is a general tendency to replace fodder roots by kale, rape, and similar crops requiring less labour. Sugar beet has never been of any importance. The soils are not particularly suitable and factories are too far distant to make it a profitable crop. Arable farmers in the county have, therefore, never had much assistance from the sugar beet policy, and it is not surprising that they should have turned to grass as a way out of the difficulties of the post-war years. The area of permanent and temporary grass together accounts for 70 per cent. of the total cultivated area in 1935. The lack of variety in the cropping of the county may be further illustrated by the fact that the acreage of permanent and temporary grass and wheat accounts for rather more than 80 per cent. of the total cultivated area.

With an increased amount of grassland in the county it is natural to expect a corresponding increase in the livestock carried. Although, taken as a whole, livestock has increased, it has only done so in certain directions. There have been, in fact, two important declines in numbers of stock. The number of horses fell by 6,700 (36 per cent.) between 1911–13 and 1935, and of this 5,500 occurred in work horses. This is the effect of the withdrawal of land from agriculture, of the fall in the arable area and of the introduction of tractors and other forms of power. The latter development has been very considerable all over the county, and particularly on the large arable farms in the north, north-west and south.

Sheep, too, have shown a tendency to decline, although the numbers have fluctuated considerably from time to time. The best measure of the change is to take the number of ewes. They numbered nearly 79,000 in 1911–13, 43,000 in 1921, 74,000 in 1933 and 55,000 in 1935. But even more striking is the decline in "other sheep one year old and above"; these fell from nearly 35,000 in 1911–13 to 8,300 in 1935. Only those lambs necessary for replenishing the flock are now kept to this age; the fat teg has disappeared. (See Table II.)

It becomes depressing to point always to declines, but Oxfordshire farming has its brighter side as well. Oxfordshire was particularly well placed to share in the increasing demand for milk in the London area. London has been growing rapidly; there has been a vast increase in the population of the Thames valley between Reading and London; within the county border the city of Oxford nearly doubled its population in the ten years to 1931; Banbury has also grown as the result of the introduction of the aluminium industry, and to the north-west of the county Birmingham has offered an expanding market for milk produced in the county. It was to be expected, therefore, that the number of cows should show a large increase. Between 1911–13 and 1921 the numbers went up by only 2,300 to 25,179, but since then the number has risen by as much as 10,000 head to 35,148 in 1935. In the Cotswolds, on the chalk and elsewhere in the county there have been many newcomers to milk production, while those already in the industry have taken advantage of the favourable market to increase their herds. The numbers of other cattle have remained relatively steady. There has been a tendency for the younger classes to increase in sympathy with the number of cows, for in Oxfordshire it is the general practice to replenish the herd from home-bred stock.

Even more striking than the rise in the number of dairy cattle is the increase in pigs and poultry. The former rose in numbers from 29,723 to 45,004 and the latter from 375,887 to 637,176 between 1911–13 and 1935. Most of the increase has taken place since 1921. The development of these branches has been general throughout the county.

TABLE II.

OXFORDSHIRE—NUMBERS OF LIVESTOCK; JUNE 4TH.

	1911–13	1921	1926	1933	1935
Horses for agriculture	12,698	11,104	10,444	8,214	7,129
Stallions	93	92	29	59	73
Unbroken, 1 year and over	2,823	2,711	1,574	870	962
Under 1 year ..	1,074	968	411	378	417
Other horses	2,733	3,154	2,770	2,007	2,131
Total horses	19,421	18,029	15,263	11,528	10,712
Cows in milk .. / Cows and heifers in calf but not in milk	22,851	25,179	29,537	33,915	35,148
Other cattle:					
2 years and above	15,677	13,242	14,725	14,105	14,575
1 year and under 2	16,586	11,112	17,253	20,409	17,849
Under 1 year ..	13,880	13,943	16,673	19,434	14,484
Total cattle*	68,994	64,281	79,207	89,026	83,688
Ewes	78,682	43,146	63,108	73,724	54,650
Other sheep:					
1 year and above ..	34,840	28,659	27,824	18,163	8,302
Under 1 year ..	82,331	48,800	73,139	84,556	63,219
Total sheep†	195,853	122,603	166,233	179,411	128,337
Sows	4,624	4,306	3,816	5,598	6,436
Other pigs	25,099	22,738	21,793	32,041	38,101
Total pigs‡	29,723	27,370	25,916	38,104	45,004
Total poultry ..	(1913) 375,887	341,738	435,692	666,306	637,176

* Includes bulls. † Includes rams and ram lambs. ‡ Includes boars.

Fewer horses and fewer sheep, but more cows, pigs and poultry are the chief changes in livestock in the county.

ORGANIZATION OF FARMING.

(*a*) LIVESTOCK AND LIVESTOCK PRODUCTS.—*Cows.*—As milk production is by far the most important source of income of Oxfordshire

farmers, it must be given pride of place in the discussion of the county's farming. The Dairy Shorthorn is the predominating breed, but there are some herds of Guernseys, Jerseys and Friesians. In order to improve the quality of the milk a good many farmers keep a few cows of the Channel Islands breeds in their herds, while for the same purpose there are a number of herds of Guernsey-Shorthorn crosses. Ayrshires are coming into prominence, and the number of herds of this breed has been increasing in recent years.

Great improvement has taken place in milk-production methods generally, and milk from the county is now a better, cleaner and more wholesome article than formerly. Out of some 1,800 herds in the county, 185 are accredited and there are 32 producers of tuberculin-tested milk. Of these herds 137 are over 20 cows, and 80 are under 20 cows, the total number of cows in accredited herds being about 6,100, or about one-sixth of the total cows in the county. Improvement in conditions of production has not been secured without a good deal of effort in one direction or another. Distributors have contributed to the raising of the standard by insisting on the introduction of sterilisers, and in some cases by refusal to accept supplies from other than accredited herds. For the last ten years the county staff, too, has been actively engaged in getting better methods of production adopted. Buildings have been much improved, but there is yet much to be done to them, especially on the smaller farms, and in providing satisfactory water supplies generally.

Rationing and general management of the cows has also improved greatly since the war, and milk yields have increased in consequence. Perhaps the most outstanding development in dairy farming in the county has been the mechanisation of milking. It is estimated that almost half of the larger herds are now milked by machine. The movable open-air bale is also used and there are three herds in the Cotswolds which are run on this method. The fixed bale has also been introduced where the cost of improving buildings was prohibitive.

Equally outstanding is the development in transportation of milk from the farm. Except for local supplies, which are still handled by farmers' transport, the large distributing firms now collect milk by motor from the farms or nearest road point all over the county, and take it direct to London or to local depots. In consequence the amount of rail borne milk has declined very appreciably. The coming of motor transportation too has opened up areas in the north of the county for milk production which were hitherto engaged in stock raising.

Sheep.—I will deal with sheep farming next, not so much because of its importance but of the almost revolutionary changes in practice which have occurred since the war. In the milk-producing districts of the valleys and clay areas small flocks both of the arable and grass breeds were usually kept as complementary to the dairy herds. They were replenished entirely from home-bred stock. Some of the lambs were sold fat from the grass and the remainder as stores during the autumn. On these farms the system has not altered appreciably, although more flocks of the grass breeds are carried and more of the lambs are fattened.

The changes in sheep farming methods have taken place in the arable areas of the Cotswolds and the Chilterns. Much of the land in these districts has been laid down to grass, and the Oxfords and the Hampshires, which used to be the chief sheep of the fold, have given way to a great variety of grass breeds and their crosses. Perhaps the most important of these is the half-bred, but with so much indiscriminate crossing it is difficult to say what are the present breeds. The Welsh mountain and the Ryeland breeds are also popular. The general practice is to use down rams of the Oxford, Hampshire, Suffolk and Southdown breeds, and by this means an early maturing lamb can be secured.

The coming of the grass breeds has meant the disappearance of close folding and of the succession of arable crops, and there has been a shift also in the nature of the production. Easter lamb was only of importance for supplying local demand, the chief product of the arable flock up to the end of the war being the fat teg finished on roots in the winter and spring. The change to grass flocks has generally meant a quicker turnover as most of the lambs are finished on the grass and the remainder on a few acres of early turnips, specially grown for the purpose.

The new methods of sheep farming have been dictated by a variety of circumstances, of which (*a*) the unprofitableness of arable farming, (*b*) the difficulties of getting good shepherds, and (*c*) the shift in the consumers' demand to a smaller joint are the chief causes. All these have operated in varying degrees to the spread of the grass flocks in the arable districts.

Pigs.—The development of pig-keeping, which has been so marked in recent years, has not followed orthodox lines. On most farms in the county pig-keeping is a side line in the farming business, and with some exceptions it has remained so. The exceptions are noteworthy. In the north and west of the county there are now many large herds, and bacon and pork production has become an important part of the farm income. The pigs are run as a

specialist enterprise, usually on an open-air system on permanent grass or seeds leys, but otherwise they have little connection with the system of farming. The food is mostly bought.

Even more noteworthy is the change from the old-fashioned pig-sty to the modern types of farrowing and feeding houses, and everywhere throughout the county examples of the new houses are to be found. Since the recommendation of the Pig Commission there has also been a change in the breeds of pigs kept. The Wessex and the Middle White sows have become popular and are commonly crossed with the Large White. A few years ago the Large Black was of considerable importance, but numbers have dwindled. The Berkshire is still used for the production of porkers for the London trade, and in the north of the county the cross-bred Tamworth-Berkshire, the Oxfordshire "breed" of pigs—"the black and sandy"—is popular for the midland pork trade.

Poultry.—Although poultry farming has developed all over the county, in the main it still remains a small-scale industry and an adjunct to the general farm business. On most farms the flocks are between 100 and 200 in size. These are mainly of Rhode Island Reds a breed which has been found most suitable both for the low-lying and high-lying districts of the county. There is a general tendency amongst farmers to give up breeding their own stock, and instead to buy day-old chicks from specialist breeders. While, however, the majority of the fowls in the county are comprised in small flocks there has been a steady development both in specialised poultry farms and in the large poultry enterprise on general farms.

At present there are between seventy and eighty specialist poultry farmers in the county, and it is a point of some importance to note that the average size of flock on these farms has increased tremendously in the last ten years or so. Previously many of these poultry farms had less than 500 birds, and under such conditions it was difficult to get a livelihood, but at the present time the more common number would be between 1,000 to 2,000 birds. One farm has over 10,000 laying birds. These poultry farms conduct a varied kind of business, including the sale of day-old chicks, hatching eggs, table birds as well as fresh eggs. The tendency is for this class of poultry farmer to go in more for breeding stock in order to supply hatching eggs, day-olds and stock birds for the general farmer.

Poultry has also become an important branch of farming on mixed farms in the county, and along with pigs has been responsible for the decline in sheep and fat bullocks. There are about thirty farms in the county on which poultry has become a special branch,

and the flocks range from about 500 birds upwards. On one-third of them the flocks number 2,000 and over, and on another one-third the flocks are between 1,000 and 2,000. About half of these farms replenish their stock by the purchase of day-old chicks and pullets, the other half doing their own incubating. The practice of buying day-old chicks for replenishment is increasing. Egg production is the chief aim on most of these farms, but a certain amount of business is also done in table birds and occasionally breeding stock is also sold.

Farmers are giving up the keeping of poultry in the old fashioned poultry houses in the farmstead; movable houses are in use everywhere and more recently folding units have been introduced. This is largely the result of the increased scale of poultry-keeping and of a general desire to give the birds fresh ground and to get more use of the manure. A great variety of houses is in use and practically every type is to be found. Some of the larger specialist farmers have found the folding unit unsuitable, partly because of the difficulty of moving the houses on heavy and uneven land, and partly because of the unsatisfactory egg production which they get in them.

Ten years ago the County Organizer estimated that egg production did not amount to more than 100 eggs per bird per annum. In the Flock Performance Scheme conducted by the County Council,* an average yield of between 140 and 160 eggs from pullets, and of 110 to 140 eggs from hens was secured; although the improvement in general may not be so great as these figures suggest, there is every reason to believe that egg production is at least 20 per cent. higher than it was ten years ago. Farmers generally are not attempting to force production, and are content with moderate yields. Oxfordshire poultry farmers, like others elsewhere, have been experimenting with rations, and at the present there is a tendency to reduce the percentage of protein in the ration and to go back to wet in place of dry mashes.

Until quite recently the method of marketing eggs, not sold privately, was generally through higglers and also through certain livestock markets. The facilities provided at these markets were on the whole satisfactory, and at the present time there are one or two such markets which handle considerable quantities of eggs from the farms, but at other markets of this type the numbers of eggs sent in has been declining. This is the result of the coming of the packing station, of which there are a number in Oxfordshire

* Flock Performance Scheme and Egg Yields in Oxfordshire, A. Bridges. *Journ. of the Ministry of Agriculture*, June 1936.

and surrounding counties. The tendency for farmers to dispose of their eggs through the packing stations, which collect direct from the farm, is increasing, and is a welcome development in the marketing of eggs, as by this method it is possible to maintain a high reputation for freshness and soundness of Oxfordshire farm eggs.

(*b*) CROPS.—With so little variety in the crops grown in the county there are no special features in rotations or in methods of cultivation. In the arable areas the four-course shift, or modifications of it, is most commonly practised, although occasionally the seeds may be left down for two or three years. Often a second straw crop is taken after roots and also after seeds if the land is clean enough. On the lighter lands, temporary leys get very thin and weedy after the second year, and the system of long leys is not, therefore, so suitable for the county as for the moister and more equable climate of the west and north-west of England.

Wheat is the outstanding corn crop, and the varieties grown are Square Head Master, Standard Red, Wilhelmina and Victor, with Little Joss on the lighter land. Practically all the wheat is autumn sown, and owing to the difficulties of obtaining satisfactory tilths in the spring, Oxfordshire farmers endeavour to sow as much corn as possible in the autumn. The use of tractors has enabled them to do this more easily than when horses were used. Barley, however, is almost entirely a spring-sown crop and the principal varieties are Spratt Archer and Plumage Archer. Chevalier is no longer grown as it is too weak in the straw. Both winter and spring oats are grown. Grey Winter, Victory and Abundance are the chief varieties.

Oxfordshire soils are not generally deficient in lime. It used to be the practice on the Chilterns to apply a dressing of chalk dug from the sub-soil once in the rotation, but this has fallen into disuse. Artificial fertilizers are used freely, and it is becoming more common for farmers to purchase compound or the new concentrated fertilizers rather than do their own mixing. It is a general practice to apply top dressings of nitrogenous manures to corn. An application of basic slag is the chief treatment for grassland and it is the most effective phosphatic manure on the heavy clays. On the whole, however, the soils do not justify very heavy dressings of fertilizers and "little and often" is the slogan of Oxfordshire farmers.

I have said that there are no outstanding features in the farming of the county. Market gardening is not a large industry; it is practised to a certain extent around Oxford, Banbury, Carterton and Henley. A large number of farmers grow sprouts and vegetables for market. They have come into business to fill the gap

caused by the loss of market garden land round Oxford for building developments. There is very little glass, but it is increasing in small units. Fruit also is a scattered industry. Here and there are a few orchards and the best known of these are the Chiltern cherry orchards. Watercress is grown at the foot of the Chilterns and violet growing is an enterprising industry at Stanton Harcourt. Little difficulty is experienced in disposing locally of all the seasonal produce grown in Oxfordshire, and it may be said that in the last two or three years there has been a gradual development in horticulture in the county.

I ought to mention that there are two arable farms in the county on which no livestock is kept. On the first of these fertility has been maintained for the last thirty years by means of artificial fertilizers and the ploughing-in of the aftermath of the seeds leys and green manures of mustard and trefoil.* The second of these is a fully mechanized corn growing farm, on which the cultivations and harvesting are carried out by tractors ; a combine harvester-thresher is used and there is a grain dryer. This farm has been without livestock for the last five years. All the produce, including some straw, is sold off.

LABOUR.

I conclude by giving you a short account of the personnel of the industry. I doubt if any county in England can show such a decline in the number of agricultural workers as Oxfordshire. In 1911 there were some 12,000 workers on farms in the county. By 1931 the number had fallen to almost half, actually 6,600, equal to between one and two men per 100 acres. This decline has been very pronounced among shepherds, horsemen and general labourers. The numbers of cattle-men have been better maintained.

TABLE III.

OXFORDSHIRE—AGRICULTURAL LABOURERS†

	1923	1926	1933	1935
Regular workers:				
Males 21 years old and over ..	6,949	7,650	5,742	5,508
Males under 21 years old ..	1,931	1,700	1,159	960
Women and girls	306	291	222	203
Casual workers:				
Males 21 years old and over ..	1,188	962	753	559
Males under 21 years old ..	333	213	67	69
Women and girls	211	138	59	51

* *Progress in English Farming Systems.* IV. Another Departure in Plough Farming. C. S. Orwin. Oxford Clarendon Press, 1930. 1s. 0d.

† Ministry of Agriculture and Fisheries, Official Statistics.

TABLE IV.

OXFORDSHIRE—AGRICULTURAL WORKERS*

	Males			Females		
	1911	1921	1931	1911	1921	1931
Farm bailiffs	265	276	112	—	3	—
Farm foremen			57			
Agricultural labourers and farm servants	12,247	9,631	6,660	59	184	51
Shepherds	733	332	256	—	2	2
Employed in tending cattle ..	1,261	1,031	998	27	80	33
Employed in tending horses ..	2,293	1,724	1,016	—	1	1
Not otherwise distinguished ..	7,960	6,544	4,390	32	101	15

* Census of Population, 1911, 1921 and 1931.

There are several reasons for the serious decline in numbers of farm workers. The withdrawal of land for non-agricultural purposes has been one cause; the decline in arable cultivation has been another; and these have lessened the demand for labour. But equally important is the competition of industry for labour. Oxfordshire was one of the counties in which the remuneration of agricultural labourers was low and there has always been a great temptation for men to leave the land for other occupations. During the latter part of the nineteenth century when earnings in the county were between 12s. and 15s. a week there was a saying which illustrated the superior attraction of the police or the railways over agricultural jobs.

"Policeman or the railway, Bobby or the line,
Five and twenty bob a week, plus the overtime."

To-day when farm workers earn from 32s. 6d. to 40s. a week it is not so much the police or the railway which draw men from the land in Oxfordshire, but the ever increasing demand of the motor, pressed steel, cement and aluminium industries. Government departments and local authorities, in a variety of ways, also compete with farmers for labour and in the face of more attractive conditions of work and better pay farmers cannot retain their men.

Perhaps the most serious aspect of the present labour situation in the county is that there is very little recruitment of boys and young men to farm work. In 1923 there were 1,931 permanent male workers under 21 years old on Oxfordshire farms; by 1935 there were less than 1,000. During the period, casual workers of the same age class fell from 333 to 69. The position is such that in a great many parts of the county there are no boys or young men

on the farms. It is not surprising, therefore, that farmers have turned to grassland on the one hand and to mechanical power on the other to help them out of their labour difficulties. As previously mentioned a great many famers have introduced milking machines and the process is continuing. In the arable districts most of the farms have tractors; and haymaking and harvesting are fully mechanized. One of the results of mechanization is that the farmer and his family now do a considerable part of the work of the farm since there is a reluctance to put expensive machines in the care of paid hands. The inability to get labour is also making farmers do more manual work than formerly.

No account of Oxfordshire farming would be complete without some reference to the position of the landlord. Oxford Colleges, which are large landowners in the county, have retained their estates, but many private estates have been broken up. Home farms, too, have disappeared and on this account there is less demand for bailiffs and people of the managerial type. On the other hand there has been a noticeable influx recently of business men who take farms and use them for residential purposes, modernizing both the houses and the farm buildings.

THE TREATMENT AND DISPOSAL OF WASTE WATERS FROM THE MILK INDUSTRY*

By A. Parker,

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Introduction.

During recent years many rivers and streams in this country and abroad have been badly polluted by discharges of waste waters from dairies and from factories making cheese, butter, condensed milk and other products from milk. There have also been difficulties at a number of sewage disposal works as the result of discharges of relatively large volumes of the wastes into the public sewers. Within the last few years, the need for the development and application of satisfactory methods of dealing with the waste waters has become particularly urgent with the expansion of the industry and the establishment of large central depots and factories, each receiving the milk from many farms.

Three or four years ago the Water Pollution Research Board initiated an intensive investigation. Though the investigation has not yet been completed, it has already provided results of considerable practical value. It is the purpose of this paper to give a brief description of those results.

In attempting to solve any problem of treatment and disposal of trade waste waters, the first step should always be to consider the practicability, taking costs into account, of so modifying the manufacturing processes that the wastes need not be produced or that the polluting matter carried away in the wastes is greatly reduced in quantity. Methods of purification of waste waters should only be considered after all practicable modifications in the factory processes have been adopted to reduce the polluting character of the wastes, or to re-use them in the factory. Frequently the polluting character of the waste waters can be reduced by reducing losses of valuable materials in the factory, or by recovering products or by-products of value. This is the line of attack which has been followed in the Water Pollution Research Board's investigation of the problem of pollution by the waste waters from the milk industry.

* Paper read at Oxford, July, 1937.

Nature of the Waste Waters.

The investigation has shown that even at milk collecting and distributing depots, where the milk is received only for cooling, pasteurizing and distribution, the waste waters from washing the delivery churns, coolers, pasteurizers, tank wagons, other equipment and the floors frequently carry away between 0·5 and 1·0 per cent. of the milk received. This means that the waste washing waters from a depot handling 10,000 gallons of milk per day may contain 50 to 100 gallons of whole milk.

The volume of waste washing water in relation to the volume of milk handled varies considerably at different depots. If the volume of washing water is about the same as the volume of milk handled, 10,000 gallons of milk per day in a collecting and distributing depot may give rise to 10,000 gallons of waste water containing 0·5 to 1·0 per cent. of milk.

The most satisfactory method of measuring the relative polluting character of milk washing water is to determine the quantity of dissolved oxygen taken up by a measured volume of the waste when it is mixed with aerated water and incubated for five days at 20° C. As measured by this test,* water containing 1 per cent. of whole milk has a biochemical oxygen demand, as it is often called, of about 120 parts per 100,000 parts. Average domestic sewage has a biochemical oxygen demand of about 40 parts per 100,000 parts and the average volume of domestic sewage per head of the population per day is approximately 25 gallons. A volume of 10,000 gallons per day of waste water containing 1 per cent. of milk is thus equivalent in its polluting effect on a stream to the domestic sewage from a population of about 1,200 people.

From factories making condensed milk, cheese, butter and other products, in addition to washings from delivery churns there are waste waters from washing evaporators, cheese vats, butter churns and other equipment. Even when care is exercised to prevent large losses of milk, of the main products and of the by-products skim milk, whey and buttermilk, the waste washing waters from cheese and butter factories contain organic matter equivalent to about 2 per cent. of the milk handled. Frequently the waste washing waters from cheese and butter factories contain organic matter equivalent to 3 or 4 per cent. of the milk handled, and 6 to 8 per cent. has been found at some factories.

* *Ministry of Health : Methods of Chemical Analysis as applied to Sewage and Sewage Effluents*, p. 45. H.M. Stationery Office (1929). Price 2s. 6d. net.

In the past some factories have looked upon whey and buttermilk as waste materials and have discharged them into the nearest streams with disastrous polluting effects. Whey, for example, has a biochemical oxygen demand of 4,000 to 5,000 parts per 100,000 parts and is at least 100 times as strong in polluting character as an equal volume of crude domestic sewage.

In other words, if the whole of the whey from a cheese factory handling 10,000 gallons of milk per day were discharged into a stream, its polluting effect would be about the same as that of the crude domestic sewage from a town with a population of 40,000 to 50,000 people. Whey and buttermilk should be treated as valuable by-products, not as waste materials. They have high food values and can be utilized as food or for the preparation of foods. There is a market for dried whey and buttermilk and there are indications that the market can be further developed.

Modifications to Reduce Losses of Milk, etc., in the Waste Waters.

In the early stages of the Water Pollution Research Board's investigation, it was concluded that the quantities of polluting matter carried away in the waste waters from the various branches of the milk industry can be considerably reduced by simple and inexpensive modifications in the operations within the factories to reduce losses of milk and of the products and by-products. At many depots and factories the delivery churns are rapidly emptied and insufficient time is allowed adequately to drain the churns before they are transferred to the washers. By installing a simple drainage rack with a milk collecting channel beneath and allowing the churns to remain in an inverted position on the rack for between one and two minutes, the quantity of milk carried away in the water used for washing the churns can be reduced from more than 0·5 per cent. to less than 0·25 per cent. of the milk handled.

This represents a saving of at least 10,000 gallons of milk or £750 per annum, with milk at 1s. 6d. per gallon, for a factory receiving an average quantity of 10,000 gallons of milk per day. Such a saving would within two or three years be greater than the capital cost of the plant required to treat the milk washings to render them suitable for discharge even into very small streams.

Improvements can usually be made also in the methods of draining and washing cheese vats, butter churns and other equipment to bring about considerable reductions in the quantities of whey, buttermilk and other products carried away in the waste waters. Cheese vats and butter churns, for example, after the

removal of whey and buttermilk, should first be washed with small quantities of water. which should then be added to the whey and buttermilk. Subsequent washings with larger quantities of water to be discharged as wastes would then contain much less polluting matter.

There is also room for improvement in the design or method of operation of condensers for whey and buttermilk; more than 5 per cent. of the whey, for example, is frequently carried over as a spray with the evaporated water from the condensers—apart from occasional loss due to a boil over.

Modifications of the kind suggested not only result in direct savings in the factory but reduce the size and cost of construction and operation of the plant required for the treatment of the waste waters.

TREATMENT OF THE WASTE WATERS.

When all practicable steps have been taken at the depot or factory to reduce to the minimum the losses of milk and of the products and by-products, the waste washing waters still require purification to make them suitable for discharge into most of the rivers and streams in this country. The investigation has, therefore, included a study of possible methods of purifying the wastes.

In the first place numerous experiments were carried out for the Department in the laboratories of the Rothamsted Experimental Station. These experiments indicated that waste waters containing polluting matter in a concentration equivalent to as much as 1 per cent. of milk might be satisfactorily purified by either of two methods. By the first method the waste waters, after simple sedimentation to remove suspended solids, are biologically oxidized by aerated or so-called activated sludge. According to the second method, the wastes are stored in tanks for one or two days to allow them to ferment; this causes the separation of fat and other solid matter as a sludge on the bottom of the tanks and as a scum on the surface of the liquid. The separated liquid is then biologically oxidized in a percolating filter. The objections to preliminary fermentation are that it increases the quantity of sludge for disposal and it may give rise to unpleasant odours in warm weather. Direct treatment of the waste waters by biological filtration, without preliminary fermentation, however, led to the accumulation of solid matter in the top layers of the filter, which in consequence soon became clogged and inoperative.

Independent experiments by Mr. H. C. Whitehead (a member of the Water Pollution Research Board) and the late Mr. F. R. O'Shaughnessy in the laboratories of the Birmingham, Tame and

Rea District Drainage Board, showed that preliminary fermentation is not necessary if the wastes are first diluted to contain the equivalent of only about 0·2 per cent. of milk. Two percolating filters in series are employed and the order of the filters in series is changed every two or three weeks. With this procedure, the slimy solid matter deposited in the top layers of the primary filter is oxidized or washed away when the filter occupies the secondary position and receives treated effluent from the other filter.

At this stage the industry agreed, through the Milk Marketing Board and the Scottish Milk Marketing Board, to co-operate in the work and to contribute towards the cost; the industry has now contributed nearly £10,000. Following this arrangement, two plants for experiments on a large scale were erected by the Department at the collecting and distributing depot and cheese factory at Ellesmere, Shropshire, where facilities have been provided by United Dairies, Ltd. The plants, which were designed by Mr. H. C. Whitehead, were completed and put into operation in August, 1935. One plant is designed for the treatment of the wastes by the activated sludge process with aeration by bubbles of air through porous plates. The other plant includes two percolating filters, each 25 ft. in diameter; liquid can be passed through the filters in either order in series as required. A description of the two plants, illustrated by photographs, is given in the Annual Report of the Water Pollution Research Board for the year ended 30th June, 1936.*

Waste waters required for the experimental plants are collected in storage tanks with a total capacity of about 10,000 gallons. Milk washings, whey washings, or mixtures of the two can be discharged from the factory into these tanks as required. The collecting and storage tanks are necessary, as the rate of production of the waste waters and the concentration of polluting matter in them vary considerably during the day and no waste waters are produced for several hours during the night; the capacity of the tanks is sufficient to enable the experimental plants to be supplied with crude liquid throughout the 24 hours of the day and night.

The two plants have now been in operation under various conditions for about two years, without any serious difficulty.

Activated Sludge Plant.

The activated sludge plánt includes a primary sedimentation tank, two aeration tanks, a final sedimentation tank, pumps, air compressor, flow gauges and other equipment.

* H.M. Stationery Office (1937). Price 1s. net.

From the collecting and storage tanks crude liquid is pumped to the primary sedimentation tank. Settled crude liquid enters a small steel tank containing V-notch flow gauges with floats and indicators. In this tank the liquid can be diluted with measured proportions of water or purified effluent. After leaving the gauging and mixing tank, the liquid flows by gravity into the two aeration tanks, which can be operated in parallel or in series. Each tank is rectangular in horizontal section and is 16 ft. long, 8 ft. wide and about 6 ft. deep. At the base of the tank there are channels with porous plates through which air is blown continuously from a compressor. Liquid and activated sludge flow continuously into the tanks, under and over baffles, and out over weirs into the final sedimentation tank. The activated sludge was produced in the first place by the aeration of milk washings.

Settled effluent from the final sedimentation tank flows into a sump to be discharged into the neighbouring brook, or part can be returned to dilute settled crude liquid from the primary sedimentation tank. Most of the sludge from the final tank is returned as a continuous stream, through a flow gauge, to mix with the crude liquid entering the aeration tanks. Surplus activated sludge and sludge from the primary sedimentation tank is discharged to a sludge-drying bed.

Biological Filtration Plant.

The biological filtration plant includes a primary sedimentation tank, a small tank in which the settled crude liquid is diluted with water or purified effluent, two percolating filters, two sedimentation tanks for the treated effluents from the filters, and pumps, flow gauges and other equipment to enable the conditions of operation to be altered as required.

Crude liquid from the collecting and storage tanks is pumped through a small chamber with V-notch flow gauge and indicator to the primary sedimentation tank. From this tank the settled liquid enters a small tank in which it is mixed with a measured proportion of water or of purified effluent from the plant. Throughout the experiments so far made, purified effluent has been used as the diluent, usually to give a mixture with a biochemical oxygen demand of 20 to 30 parts per 100,000 parts, equivalent to 0·2 per cent. of milk.

After leaving the mixing and gauging tank, the liquid flows by gravity to be distributed over one or other of the two percolating filters, A or B. Each filter is filled to a depth of about 4 ft. 6 in. with hard metallurgical coke, graded ¾ in. to 1½ in. Primary effluent from the first filter, which may be A or B, enters a

sedimentation tank. It is then pumped to the second filter and the effluent from this filter passes through a final sedimentation tank. Part of the final effluent is pumped back to the gauging and mixing tank to dilute the settled crude liquid before filtration; the remainder is discharged to the brook. Sludge from all sedimentation tanks is discharged periodically to the sludge-drying bed.

In the experiments so far carried out, filter A has been used as the primary filter, with filter B as the secondary, for one to three weeks; then filter B as the primary and A as the secondary for a similar period, and so on.

EXPERIMENTAL RESULTS.

(*a*) *Activated Sludge Process.*—As soon as the construction of the plants had been completed in August, 1935, the activated sludge plant was filled with water from the brook to test the various parts and the supply of air to the aeration tanks was begun. The water was then gradually displaced by milk washings—without whey washings—which were diluted, after leaving the primary sedimentation tank and before entering the aeration tanks, with several times their volume of water. After a few weeks, treated effluent from the plant was used as the diluent and the proportion of diluent was reduced.

Some time elapsed before a sufficient quantity of activated sludge was produced and a further period of operation of the plant under different conditions was necessary before final effluents of the desired quality (biochemical oxygen demand less than 2 parts per 100,000 parts) were obtained. Experiments on the treatment of milk washings in the activated sludge plant were continued until May, 1937, with the object of determining the maximum capacity of the plant consistent with the production of a final effluent of high quality.

With the maximum load of milk washings successfully treated by the plant, the aeration tanks received 6,300 gallons per day of settled crude liquid with a biochemical oxygen demand of approximately 50 parts per 100,000 parts. The volume of sludge circulated with the 6,300 gallons of liquid was 2,400 gallons so that the rate of flow through the tanks was equivalent to a period of aeration of 24 hours. Under these conditions the final effluent had a biochemical oxygen demand of about one part per 100,000 parts and fish lived in this effluent. This rate of treatment is somewhat less than that usual at sewage disposal works in the treatment of domestic sewage by the activated sludge process, due allowance being made for the difference in the biochemical oxygen demand of the crude liquids.

Equally good results are being obtained in experiments now in progress on the treatment of mixtures of milk washings and whey washings.

(*b*) *Biological Filtration.*—In beginning the operation of the biological filtration plant, water was first supplied to the plant to test the various parts. Crude milk washings, without any whey washings, were then run into the first sedimentation tank until the biochemical oxygen demand of the settled liquid reaching the primary filter had risen to about 20 parts per 100,000 parts. As the water first supplied to the filtration plant was gradually replaced by milk washings, settled crude liquid from the first sedimentation tank was diluted with final treated effluent to ensure that the biochemical oxygen demand of the liquid distributed over the primary filter did not exceed about 30 parts per 100,000 parts.

From August, 1935, to the end of March, 1936, 12,600 gallons per day of diluted milk washings with a biochemical oxygen demand of 20 to 30 parts per 100,000 were passed through the two filters in series and the order of the filters was changed every three weeks. This rate of flow is equivalent to 80 gallons per day per cubic yard of filtering medium in the two filters, or 160 gallons per day per cubic yard in each filter. Under these conditions the biochemical oxygen demand of the effluent from the primary filter was about 2·5 parts per 100,000 and that of the final effluent after treatment in the two filters was less than one part per 100,000 parts. Tests over long periods showed that the final effluent supported fish life.

In view of these excellent results, the rate of supply to the filters of settled liquid with a biochemical oxygen demand of 20 to 30 parts per 100,000 was increased in April, 1936, to 120 gallons per day per cubic yard of filtering medium in the two filters. This increased rate did not cause any deterioration in the quality of the final effluent. Towards the end of June, 1936, the rate of flow was further increased to 160 gallons per day per cubic yard of medium in the two filters. With this high rate of flow the plant gave a final effluent of better quality (biochemical oxygen demand less than 0·5 part per 100,000) than previously obtained at the lower rates of flow, possibly owing to higher temperatures in the filters during the summer months.

In March, 1937, the rate of flow was increased to 240 gallons per day per cubic yard of medium in the two filters together and this rate was maintained until about the end of May. The final effluent remained of high quality with a biochemical oxygen demand of less than one part per 100,000 parts, but it was necessary to change the order of the filters every week or ten days, instead of

only once every three weeks, to ensure adequate removal of the solid matter deposited in the top layer of the primary filter.

A rate of flow of 240 gallons per day per cubic yard of filtering medium with a liquid with a biochemical oxygen demand of 20 to 30 parts per 100,000 represents a rate of treatment much greater than that usual in sewage disposal works in the treatment of domestic sewage by single filtration. Under expert supervision the high rate of flow of 240 gallons per day per cubic yard could be maintained with good results. A rate of 160 gallons per day per cubic yard, however, seems to be the maximum advisable under the conditions in milk depots and factories.

The plant at Ellesmere is now being supplied with a mixture of milk washings and whey washings. After sedimentation the mixture is diluted to give a liquid with a biochemical oxygen demand of 20 to 30 parts per 100,000, and this mixture is being passed through the filters at a rate of 160 gallons per day per cubic yard of filtering medium. Final effluents with a biochemical oxygen demand below one part per 100,000 parts are being obtained and the filters are not showing signs of becoming clogged.

THE USE OF DETERGENTS IN DAIRY WORK*

By W. L. Davies,

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Detergents are chemical reagents which are used as dilute aqueous solutions to facilitate the removal, by washing, scouring or abrasion, of coatings of foreign matter adhering to surfaces. With glass or metal surfaces, these reagents consist wholly of sodium salts of weak acids or caustic soda itself, the dissociation of the salt giving the necessary alkalinity to the solution. The range of sodium salts used as detergents is limited, since the cost is of primary importance. The simplest and cheapest compounds are caustic soda and washing soda (or soda ash). Owing to certain drawbacks in the action of these two reagents, other sodium salts such as the meta- and ortho-silicates, and triphosphate and hexa-metaphosphate are used either alone or in conjunction with cheaper salts.

Evaluation of detergent strength.—In order to evaluate these different alkaline reagents on a common basis, a factor common to all, namely the "available alkalinity" has been instituted, i.e. the titration values of solutions of these salts to an end-point with phenolphthalein are taken as their NaOH equivalents. For the pure salts, for instance, soda ash (Na_2CO_3) has 40, metasilicate 66, orthosilicate 87, trisodiumphosphate 24 and hexametaphosphate 45 parts per 100, which can be regarded as available alkalinity or free NaOH. What is really measured by titration is the alkali (NaOH) equivalent of the buffer value from their pH as solutions (pH 11–13) to that of the phenolphthalein end-point (pH 8·3). It must be pointed out that most of the above salts possess qualitative properties other than alkalinity which are of value when considering the mechanism of detergent action. Detergent solutions in commercial practice can be controlled for available alkalinity on a titration basis.

Composition of milk film and milk stone.—It is necessary when considering detergent action to know the composition and the mechanism of the deposition of the films of milk residues adhering to glass and metal. Films are mainly of two types, the cemented and uncemented.

* Paper read at Oxford, July, 1937.

The cemented type, which is the harder to remove, is composed of milk fat, casein and ash precipitated by heat coagulation either in the process of heat treatment of milk in contact with metal, or in hot water treatment and baking of glass. The mineral constituents (the calcium phosphate, and calcium of casein) act as cementing agents. The terms "milk film" and "milk stone" represent different degrees only of the same phenomenon, the change into the form "stone" meaning that more mineral matter enters into the cementation process and that the film is less hydrated. Film contains up to 20 per cent. and stone above 20 per cent. of dry matter. Fat, casein and ash are roughly in the proportions they are found in milk.

Uncemented films consist of those deposited by evaporation of milk residues with or without precipitation of fat and casein by acid development. Such films are hydrated easily by water-soaking and are tractable to dilute alkaline solutions.

The mechanism of deposition of milk film on hot surfaces is based on a variety of factors, depending on the degree of heat applied to the metal, the heat stability (which mainly depends on the acidity) of the milk, the existence of a thin layer of air on the metallic surface, which depends on the wettability and the thoroughness of previous cleaning of the surface, the presence of traces of detergent or of hard water on the metal surface, and the liberation of small bubbles of gas from the milk at the metal milk surface.

Mechanism of detergent action.—Detergent action involves a variety of physical and physico-chemical reactions working together. These are: solution of part of the film, hydration (peptization) of the protein, base exchange (Na/Ca) from the protein to give a more soluble or more highly hydrated film, and mutual solution of the surface (glass) in a detergent of similar composition, which tends to disrupt the film from its base. The efficiency of these operations depends on the detergent solution and the time of reaction. In practice, the film is then removed by abrasion (on exposed surfaces), or by water jets. In most cases the softened films can be removed by brushes and thoroughly rinsed free from traces of detergent with hot water. The importance of these processes leaving the surface in a completely wettable form cannot be overestimated, hence the importance of "rinsability" of a surface after the action of the detergent.

Hardness of water.—The action of detergents is modified in a minor way only by the degree of hardness of water. Ordinary water may vary in hardness from 4° to 37° according to the source and whether water-softening has been carried out. The amount

of detergent required to soften the water is very small and can usually be neglected. A 0·1 per cent. solution of caustic soda will soften water of 80° hardness completely, so that the strength of a 1 per cent. NaOH solution is reduced only to 0·975 per cent. with water of 20° hardness.

What is of importance is the physical state of the calcium carbonate precipitated in the process. The precipitate is in a powdery crystalline form which is hard to wash off glass surfaces and which crystallizes to a hard scale in pipes and tanks. However, by the use of small amounts of phosphate or silicate, the precipitate can be maintained in flocculent form which is easily washed off. Hexametaphosphate gives a transparent colloidal calcium compound. In bottle soaking tanks, frequently made up to volume with hard water and reinforced by added detergent, a hard scale of crystalline calcium carbonate is formed. With phosphate and silicate, calcium phosphate and silicate enter into the composition of this scale and is then more furry and easier to chip off, but is still crystalline. Scale on supply pipes is also troublesome with soda ash softening, but the rate of formation is decreased by phosphate and silicate.

Corrosion problems.—A greater wear of plated metallic surface takes place through wear and tear and abrasion than by the corrosive action of alkaline detergents. Some solution of tin, however, is known to occur, and this can be minimized by the including of small quantities (0·5–1 per cent.) of sodium sulphite in the detergent mixture. The corrosion of aluminium by alkaline liquids is bound up with the physical state and purity of the metal. Crystalline or cast aluminium and sheeting below 94 per cent. purity are rapidly attacked, but polished purer sheeting is fairly resistant and the protective action of silicate and/or phosphate has been established.

Glass is etched by pure caustic soda solutions and the addition of alkali salts which confer better rinsability to the glass is advised.

Bactericidal effects of detergents.—The change of the *p*H of the medium for bacterial growth outside the toleration range of *p*H 5–9 (for most organisms) will naturally have a lethal effect. The *p*H of alkaline detergent solutions will in most cases exceed 11 and the bactericidal action will depend on the temperature of (about 130° F.), and time of exposure to the alkaline liquid and to the bacterial distribution. The solutions will generally be hypertonic to bacterial protoplasm, so that Na and OH ions will tend to diffuse into the body of the organisms. Provided that the detergent and temperature effects are sufficiently rigid there will be a considerable lethal effect during the cleansing process; once the protective action of the film

has been overcome, subsequent sterilizing operations will be more thorough.

Detergent mixtures and proprietary preparations.—Cheapness and efficiency are the main factors governing the composition of a mixed detergent. The basal compound is sodium carbonate, usually as soda ash, with additions of caustic soda, silicate and/or phosphate. The following is an example of a detergent mixture; soda ash 90, caustic soda 4, trisodium phosphate 2, sodium metasilicate 4. Variations of these amounts are permissible, e.g. for plant and glass cleaning on a small scale: soda ash 95, silicate or phosphate 5. The solutions may be made up in concentrated form, say 20 per cent., beforehand and used in diluted form. The analysis of a large number of proprietary mixtures shows that many components embracing the above acid radicles are included.

The main idea in prescribing mixtures is that it is usually cheaper to buy the ingredients singly and a variety of mixtures suitable for cleaning various parts of plant can be made up instead of using one proprietary detergent of constant composition.

Proprietary mixtures should be evaluated on available alkalinity and composition, especially their content of the more expensive ingredients. The silicate and phosphate contents are usually below 10 per cent. and the alkalinity from 20–40 per cent.

One class of detergent in common use is a jelly-like material sold in tins or drums. Members of this class contain from 40–70 per cent. of water. The greater portion of the dry matter is caustic soda (alkalinity 23–34 per cent.) with 4–18 per cent. sodium carbonate, 2–8 per cent. silicate and 2–10 per cent. phosphate. Nearly all contain small quantities of dextrinized starch to prevent the calcium carbonate from depositing on glass and generally to hold solid matter in suspension. On a comparative basis these detergents are expensive and require expensive packaging.

Strength of detergent solutions.—The strength of detergent solutions to use depends on their composition and whether they are used for hand washing. In soaking tanks, up to 2 per cent. solutions are used, but for small-area washing about 1 per cent. is preferred. As a general rule 0·5 per cent. available alkalinity is aimed at, but the strength can always be varied according to the extent and nature of the work, and the intractability of the film to be deterged. Soaking for a few hours or overnight might be required in some instances, e.g. flash pasteurizers.

It is highly important to maintain the detergent strength at its proper level. Capacities of tanks should be known and since there is loss of detergent on the outgoing vessels and dilution by water

by the ingoing vessels, the detergent should be reinforced at frequent intervals after determining the available akalinity by titration. Efficient pre-rinsing of bottles should be done to prevent excessive fouling of the detergent.

The important and time-consuming work of cleaning up plant can be simplified greatly by the wise and judicious use of detergent solutions; the appearance, serviceability and hygienic condition of such plant can be effectively maintained by close attention to detail in the management of soaking times for badly-filmed surfaces, and the proper rotation of cleaning processes.

THE CONTAMINATION OF MILK BY CHURNS*

By A. L. Provan,

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During the past few years it has been found that churns returned by milk buyers to farms in the West Midland Province are often in an unsatisfactory condition on arrival. Visits to dairies obtaining their milk from the three counties have also shown that the arrangements for cleaning and sterilizing churns are sometimes inadequate. This is important, because producers often consider that the buyer is responsible for the churns and do not treat them in any way after return to the farm, especially where they appear clean and smell sweet.

In order to decide whether commercially "cleaned" churns require any further treatment after return to the farm an investigation was undertaken during 1933–1934, when 173 churns from 12 representative buyers in Shropshire and Warwickshire were examined; since that time a further series of tests has been carried out.

TABLE I.

GENERAL CONDITION OF CHURNS AS RETURNED TO THE FARM.

		Condition of Churn				
	No. of churns examined	Good	Fair	Moist	Containing milk or dirty water	Putrid smelling
Winter ..	87	41	18	19	9	0
Summer ..	86	28	6	39	8	5
Total	173	69	24	58	17	5

Methods.—The churns remained untouched at the farm until three to four hours after their return. After examining each churn for condition, 1,000 ml. of sterile saline were used to rinse the churn and lid by thorough shaking. A sample of this rinse water was taken for examination for number of bacteria (on standard agar at 37° C.) and *Bacillus coli*.

This method has since been modified, because it was found that if the churns are treated with sterile swabs or brushes much more of the material adhering to the sides of the churn is removed than by rinsing only. In addition the number of bacteria is now determined on milk agar instead of standard agar.

* Specially contributed.

Condition of churns on return.—The 173 churns examined during 1933–1934 may be taken as representative of the churns returned to farms. Churns from each buyer were examined twice at each particular farm, in winter (October to March) and summer (May to September). In Table I, the results of the observations on condition are given.

TABLE II.

INITIAL CONTAMINATION OF MILK BY CHURNS.

				Contamination of milk					
				No. of bacteria per ml.			*Bacillus coli*		
Buyer No.	No. of farms	Period	No. of churns	Max.	Min.	Mean	Max. ml.	Min. ml.	Mean ml.
1	1	Winter	6	0	0	0	—	—	—
		Summer	6	0	0	0	—	—	—
2	1	Winter	5	2	0	0	—	—	—
		Summer	6	15,300	9	3,640	—	—	—
3	1	Winter	5	1,300	0	250	—	—	—
		Summer	5	0	0	0	—	—	—
4	3	Winter	8	570	1	92	—	—	—
		Summer	7	76	1	22	—	—	—
5	3	Winter	10	14,200	5	4,300	+1/10	—	+1
		Summer	10	71,000	116	20,300	+1	—	+1
6	2	Winter	9	2,320	0	400	+10	—	—
		Summer	7	15,400	0	3,000	+10	—	—
7	2	Winter	7	1,320	6	455	+1/10	—	+1
		Summer	8	147,000	3	22,000	+1/1000	—	+1/100
8	3	Winter	11	1,190	2	228	—	—	—
		Summer	11	36,000	1	8,000	+1/100	—	+1/10
9	1	Winter	6	129	1	24	+10	—	—
		Summer	6	73,000	12,000	37,000	+1/100	+10	+1/100
10	4	Winter	8	14	0	2	—	—	—
		Summer	8	2,740	0	520	+1	—	+10
11	4	Winter	10	56,000	1	6,700	+1/100	—	+1/10
		Summer	10	14,800	11	3,700	+1/100	—	+1/10
12	1	Winter	2	1,090	6	550	—	—	—
		Summer	2	23,700	21,000	22,700	+1/100	+10	+1/100

Churns from buyers 1 to 6 were mechanically treated, and from buyers 7 to 12, hand washed.

From Table I it is seen that more than half the churns examined gave evidence of being inefficiently washed and sterilized In the majority of cases the churns had been washed, but over ten per cent. gave visible evidence that this had not been carried out thoroughly, because the churns contained milk or dirty water. All churns examined smelt sweet during the winter months, but nearly six per cent. of the churns could be condemned by smell in summer. In some instances the churns were rusty or had ill-fitting lids, and in

this respect it was found that 17 gallon churns were inferior to the smaller types.

Bacterial contamination from churns.—In Table II the bacterial contamination which would be expected when the churns were filled with milk is given. These figures are calculated as bacteria per ml. of milk from the results of the bacteriological examination of the saline used for rinsing the churns.

Table II shows that considerable numbers of bacteria can be introduced into milk by the churn as returned to the farm. The amount of contamination varies greatly with the churns returned by different buyers and with different churns of the same batch. In most instances those buyers possessing mechanical churn washers returned a better churn than those depending upon hand washing.

In the case of buyer No. 5 a visit to the dairy showed that the mechanical washer was not being properly operated.

It is interesting to note that not only can the churns be sources of large numbers of bacteria, but they can also be the source of excessive contamination with *Bacillus coli*.

The numbers of bacteria present during the summer were much larger than during the winter and in only one instance (Buyer No. 1) were sterile churns returned in both summer and winter. The contamination which would have occurred during summer was often sufficient to nullify any good work in production, and this applies to *Bacillus coli* as well as total contamination.

During the summer of 1937, 57 churns from ten different buyers were examined at farms on which unsatisfactory results were being obtained. It is not claimed that these are representative, but it has been found that very few firms are returning churns in any better condition. These churns were examined by the modified technique described above and the results are given in Table III.

TABLE III.

CONTAMINATION OF MILK BY BUYERS' CHURNS, SUMMER 1937.

(*a*) Number of bacteria

Condition of churn	No. of churns	Number of churns with bacteria per ml. of milk: 0–100	101–1,000	1,001–10,000	10,001–100,000	100,001–1,000,000	> 1,000,000
Good	11	4	2	—	1	2	2
Fair	7	—	—	—	3	2	2
Wet	23	4	3	6	1	6	3
Containing milk or dirty water	5	1	—	—	—	3	1
Putrid smelling	11	—	—	—	—	—	11
Total =	57	9	5	6	5	13	19

(*b*) *Bacillus coli*

Condition of churns	No. of churns	Absent	Number of churns with *Bacillus coli* present in 10 ml.	1 ml.	1/10 ml.	1/100 ml.	1/1,000 ml.
Good	11	9	—	—	—	—	2
Fair	7	1	2	2	—	1	1
Wet	23	11	4	1	1	—	6
Containing milk or dirty water	5	3	—	—	—	—	2
Putrid smelling	11	2	—	1	—	—	8
Total =	57	26	6	4	1	1	19

The figures in Table III confirm those of Table II in showing that excessive numbers of bacteria may enter milk from churns during the summer months. The results obtained are much higher than those obtained in the 1933–1934 tests, and this is undoubtedly due to the removal of large numbers of organisms from the sides of the churns by brushing which would not be disturbed by rinsing. It is, however, impossible to say how many of these would be removed by the milk, but instances have been recorded in which samples containing few organisms can be obtained under the milk cooler, and millions when the same milk was sampled from the churn.

The table indicates that clean dry churns are superior to clean wet churns while, as would be expected, obviously dirty churns are nearly always the source of large numbers of bacteria.

Summary and Disscussion.—The results of the examination of 230 buyer's churns returned to producers in Shropshire and Warwickshire have shown that:

1. Churns are often returned in an unsatisfactory condition and may be the source of large numbers of bacteria including *Bacillus coli.*
2. The possible contamination is greater in summer than in winter.
3. Mechanical cleaning is usually superior to hand cleaning. This would be expected as mechanical washers are not subject to personal errors.
4. Clean dry churns are not as likely to cause excessive contamination as clean wet or obviously dirty ones, but all churns should be sterilized after return to the farm as appearance cannot be relied upon to decide whether sterilization is necessary.

> The results were obtained from churns which normally would not be used for milk until 6–20 hours later and it is probable that the contamination would be greater than that given by the above results owing to multiplication of the organisms on the moist surface and that this would be greater during warm than cold weather.

The results refer to initial contamination which would be less than would be found on testing milk on arrival at the buyers depot 3–16 hours later.

There is no doubt that the condition of churns used for transport of milk should receive more attention that it does at present. Many reports of unsatisfactory conditions of production as the result of *Bacillus coli* are undoubtedly due to the use of heavily contaminated churns. It is in the interests of both producer and distributor that milk should receive as little contamination as possible during handling prior to distribution, and the use of bacteriologically clean churns would reduce this contamination considerably.

There seems to be some need for clearing up the problem of who is responsible for the sterilization of churns. At present cleansing and presumably sterilization, is the legal responsibility of the distributor, but it is doubtful whether the most efficient commercial "sterilization" can guarantee the sterility of a vessel which will certainly not be used until 20 and perhaps 48 hours after treatment.

It is in the interest of the farmer, especially when he produces graded milk, to sterilize churns after return to the farm. At the same time this should not absolve the buyer from his obligations to return a thoroughly clean steamed churn to the farm, and this should be enforced more rigidly. If this were done and the onus of providing for the final sterility rested on the farmer, as is held by many health authorities at present, there would be no hardship to producer or distributor. But the present situation where the producer often has to clean as well as sterilize the churns is unfair.

SOME RESULTS OF ARTIFICIAL INSEMINATION IN A DAIRY HERD*

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During the two years 1935 and 1936 a proportion of the cows in the dairy herd of the National Institute for Research in Dairying were inseminated by artificial methods. The chief reasons for this were (1) To gain experience of a method which has been used with success in Europe and which appeared to possess valuable possibilities; (2) To reduce the danger of spreading abortion in a herd where attempts were being made to eliminate the disease.

We are indebted to Dr. Walton of Cambridge, for advice on the choice of apparatus and for instruction in the technique. The collection of semen was almost invariably by means of an artificial vagina of the "Cambridge" or of the "Moscow" type using a living cow during oestrus. A dummy cow was not used and on a few occasions the fluid was successfully obtained using a cow outside the oestrus period. The method described by Miller and Evans was not satisfactory; this involved massage of the seminal vesicles and ducts of the bull through the walls of the rectum. The fluid so obtained sometimes contained no sperms and the presence of epithelial cells and leucocytes suggested injury to the tissues. The semen was usually, but not always, diluted about 1 to 4 with a dilutor supplied by Dr. Walton (G.P.C.3). The cows were inseminated by means of a syringe fitted with a long vulcanite catheter; about 1 c.c. of the inseminating fluid was injected into the cervix using a speculum and head lamp. An "all glass" syringe was recommended for this work, but breakages proved so common that a glass syringe with metal plunger and nozzle was substituted without obvious ill effects or breakages.

The service records of the herd are shown in Table I, classified according to whether the matings were normal or artificial.

Twenty-one animals were unsuccessfully inseminated; of these, ten proved sterile to normal matings, five were never bred again, and six were subsequently fertile to normal matings.

Two animals which were infertile to normal matings proved fertile to artificial insemination; both these cows were old—10 years

* Paper read at Oxford, July, 1937.

and 12 years—and failure to conceive may have been due to closure of the cervix so that the sperms were unable to enter until the obstruction was overcome by insertion of the catheter.

TABLE I.

SERVICE RECORDS

		By normal matings	By artificial insemination
Total services		253	57
Number effective		98 (39%)	18 (32%)
Number of cows returning	0 times	63	14
	1 ,,	9	3
	2 ,,	10	1
	3 ,,	7	—
	4 ,,	6	—
	5 ,,	2	—
	6 ,,	1	—

It will be observed from Table I that fertility in the herd was poor: this was partially due to *B. abortus* infection which was more prevalent among the artificially inseminated animals than among the remainder of the herd. Two other factors may have reduced the effectiveness of artificial insemination, firstly, a few of the cows were not noticeably "in season," but in spite of this pregnancy occurred in one cow which had only been noticed in season 43 days previously. Secondly, when stale sperm was used, the fertility appeared to be reduced. This point is shown in Table II.

TABLE II.

INFLUENCE OF AGE OF SPERM USED

	Number effective	Non-effective
Under 12 hours	17	25
24 hours old	0	5
48 ,,	1	3
72 ,,	0	4

The normal method of storing semen was to cover all the fluid with paraffin to exclude air, to cool gradually and finally store at about 4° C.; when required for use the fluid was gradually warmed to room temperature.

The results from sperm more than 12 hours old were somewhat disappointing and only one insemination in twelve was effective. The effective sample of semen was examined microscopically at room temperature and slight motility was observed at 24 hours old. It was then diluted 1 to 4, stored a further 24 hours without paraffin and was non-motile at 48 hours old.

The number of calves resulting from normal matings and from artificial inseminations is shown in Table III.

TABLE III.

RECORD OF CALVES

		Normal matings	Artificial inseminations
Calvings	Total (including abortions)*	90 (1 twins)	17 (3 twins)
	Full time	72	10
	Premature	18	7
Living calves	Total	68	10
	Male	34	6
	Female	34	4
Reaction of cows to agglutination abortus test	Positive	39	13
	Negative	51	4

* The difference between the number of calvings noted in Table III and the effective services shown in Table I is due to a few pregnant cows which had not calved on the date the paper was read.

The larger proportion of twins resulting from artificial insemination is believed to be a chance variation, while the larger proportion of premature calvings is explained by the greater incidence of *B. abortus*. No difference in health and vigour of the calves could be observed between the two groups.

The fertility of the bulls is shown in Table IV.

TABLE IV,

FERTILITY OF BULLS

Name of bull	Normal matings: Effective	Normal matings: Non-effective	Artificial insemination: Effective	Artificial insemination: Non-effective
F.V.	3	5	10	13
L.K.O.	28	34	3	16
R.D.C.	39	80	5	8
C.R.	14	20	1	0
Others	13	17	0	1

The only bull showing a marked difference in fertility between normal and artificial matings was L.K.O. This bull had a spell of low fertility during the early part of the period under review and most of the artificial inseminations from this bull occurred during this spell of low fertility.

Artificial insemination as practised in this herd proved about as effective as normal matings but stale sperm was less effective. No insurmountable technical difficulties were encountered and no ill effects were observed on health of cows or progeny.

THE SOIL SURVEY AND ADVISORY WORK*

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Twenty-five years of advisory work, and rather more than that of soil survey, might seem to be sufficient qualification to speak on the subject of this paper. Yet I sometimes feel, as is so often the case with an investigator, that the longer I work at soil survey and advisory work, the less satisfied I am with both of these branches of agricultural science. Therefore, in what I am about to say, I shall present to you not a record of achievement, but an exposition of problems and difficulties, with some aspirations for the future.

OLD AND NEW IDEAS.

When I started soil survey in Shropshire, 27 years ago, the prevailing methods were along geological lines. The earliest workers on soil survey, notably Hall and Russell, had found that, in the south-east of England soils grouped themselves fairly well according to the geology, or more strictly speaking, the lithology. And therefore, to me in 1910 the task of the soil surveyor appeared to be simply to take the geological map and to draw representative samples of soil from the outcrop of each formation. In my preliminary survey of the soils of Shropshire, published in 1912, I attempted to do this. But there were grave difficulties. In the first place, a large proportion of the area was covered by glacial drifts, and I found that the available information on these was very scanty, so that I had, in a very rough and ready fashion, to make my own drift map as I went along. Secondly, I realized that a term such as boulder clay could cover a very wide range of soil-forming materials, not always related to the local solid geology. Thirdly, there was often a rather disconcerting variety in soils derived from the same geological parent material.

These difficulties became more pronounced when I started work in North Wales in 1912. The problem of the drifts was even more acute, and there was a more marked variation in soils derived from the same parent rock material. At the same time I found that one could also get very similar soils from different geological formations.

After the war, new ideas on soil classification began to filter in from abroad, principally from Russia, and we learnt two things from

* Paper read at Oxford, July, 1937.

these new ideas. In the first place, and this I regard as the most important lesson, we learnt that in attempting to map and classify soils the unit of classification is not simply the top soil, or even top soil and immediate sub-soil, but the soil profile, that is, the succession of soil horizons down to the geological parent material. This new standpoint was important not only for soil classification but also for the study of plant growth, and hence for practical agriculture and horticulture. Many of the problems of cropping are only soluble when the soil profile is taken into consideration. The lack of consideration of the soil profile, and the restriction of attention to the analysis of laboratory samples of surface soil, are largely responsible for the poor success which has, until recently, followed the efforts of the soil chemist to be of service to the cultivator.

But we learnt something else from our foreign colleagues. I suppose it was implicit in our earlier knowledge of soils; but acquaintance with foreign work emphasized the importance of external soil-forming factors, above all climate, in determining the character of the soil. The soil, and by the soil I mean the soil profile, is not simply the manifestation of the parent rock material from which it has developed: it reflects all the factors which have acted upon it; the influence of climate, the influence of surface relief and drainage conditions; the influence of natural vegetation, of agricultural cropping of the grazing of animals, and of the time during which these factors have operated. Indeed, so important are these external factors in determining the character of the profile that some students of the soil, particularly the Russian school, assigned a dominant rôle to the most important of all factors, namely climate, and classified soils in terms of climate, regarding geology as subsidiary.

I have put forth these abstract considerations because I wish to make it plain that the great variety in soils, a variety with which all of you are familiar, is an ordered variety and depends on the operation of a number of factors on different parent rock materials.

As an example of the variety of soils which can be encountered in association with the same parent rock material, I may enumerate briefly the kinds of soil which may be found developed from shaly rocks of Cambrian to Silurian age. In the highest parts of the mountains, the profile consists merely of a layer of fibrous peat over rock. At lower altitudes may be found under heath vegetation a peaty layer, underlain by grey loam which in turn gives place to a rusty-brown, somewhat compact, brashy horizon, which overlies brownish-grey or grey brash. Still in the uncultivated land, but

under grass and bracken, may be found a turfy layer over brownish shaly or stony soil passing to brash or rock. Where drainage is impeded, peaty soils overlaying greyish rust-mottled sub-soils may be found. In the agricultural lands may be found a range varying from shallow brownish very stony loams to deep brownish stony loams, where the drainage is free. Where drainage is impeded, there occur grey heavy loams, whilst grey alluvial soils occur in valley bottoms. All these differences are reflected in natural vegetation and in agricultural utilization. A similar range of soils may occur in association with other parent rocks, so that the possibilities of variation are very great. It may be added, however, that in the case of many formations their small extent and the moderate surface relief limit the amount of variation which may occur.

THE TASK OF THE SOIL SURVEYOR.

The task of the soil surveyor is to represent on a map all the significant kinds of soils which occur in the area to be mapped. In order that the soil maps produced may be of value, it is important to devise an agreed system of soil classification, so that the principles of mapping may be the same throughout the country. Those engaged or interested in soil survey have been in constant collaboration since 1920, and a system has now been adopted which is largely based on the procedure in the U.S. soil survey. The unit of mapping is the soil series, which may be defined as a set of soils having the same general profile characters developed from the same or similar parent material. Soil series are generally named after the localities in which they are first mapped. The series is further sub-divided into types according to texture. We have thus as ultimate units, soils such as the Penrhyn medium loam, Ebenezer stony light loam, Salop heavy loam, etc.

Since soils do not fall into such well defined genera and species as plants and animals, but show transitions from one kind of soil to another, it is often difficult to decide whether a given soil belongs to a given series. In order to meet this difficulty, a small committee has been set up to correlate soil survey work in different parts of the country, and to give official recognition to soil series found and mapped by individual surveyors. In addition, field meetings are held at intervals. In these meetings, soil surveyors map selected areas and compare results. It is satisfactory to know that methods of work have now been so well standardized that excellent agreement is shown between soil maps of the same area made by different surveyors.

Systematic soil survey work is being carried out in only a few provincial areas. Those of us interested in this work are grateful that the work is being kept alive, but we do feel very strongly that the soil survey should be extended so that there may be a prospect of obtaining a survey of the whole country. The usefulness and significance of soil maps grow in proportion to the area surveyed, for when a large area is covered it becomes possible to correlate the soils of one district with those of another.

The largest areas mapped up to the present are in North Wales and in Shropshire. Mapping is also in progress in the Bristol, Reading, and Wye areas, whilst considerable data are available for the Cambridge area. The actual maps are made on the 6-inch to the mile Ordnance Survey maps as base-maps. Up to the present comparatively little soil survey work has been published. The problem of publication is at present under consideration, but in the meantime I may mention Dr. Kay's excellent survey of the Vale of White Horse as an example of the type of publication at which we might aim. It would probably be too expensive to publish the 6-inch maps, but we might publish a series of 1-inch maps generalized from the large-scale field maps, which would be filed at the provincial centre as archives.

Whilst soil surveyors are working along generally agreed lines, there is much room for improvement and I feel that we are possibly in a position analogous to that of the Geological Survey nearly a century ago. The maps which we are producing now will need revision in the future, but I think we may set ourselves two aims, namely (1) to recognize all the important types of soil which occur, and (2) to show their general distribution.

Before turning to the advisory aspect of soil surveys, may I refer to what I conceive to be their chief justification, if justification be needed? We need a soil survey above all because it is a record and an inventory of our agricultural resources. The excellent maps now being produced under the direction of Dr. Dudley Stamp show the present utilization of our land, but the aim of the soil survey is to show the actual character of the soil throughout the country. The Geological Survey has now been in progress for nearly a century. Every civilized country regards a geological survey as a normal and necessary activity of the State. Is not a soil survey just as necessary? I will only add that the lack of a soil survey up to the present has not been an unmixed evil, for our knowledge of the soil and its classification has only during recent years reached the point at which a survey might be profitably undertaken. In those countries where a soil survey has been long

in operation, much of the earlier mapping must be regarded as obsolete and untrustworthy.

SOIL SURVEYS AND ADVISORY WORK.

I pass now to the more difficult part of my paper, namely the correlation of the soil survey with advisory work, and I may say at the outset that a soil map cannot be expected to show for every field all the information necessary in giving advice on cultivation, cropping and manuring. This would be possible only if a sample of soil from every field were taken and analysed, which is manifestly impossible with present resources, even in those areas where there is a soil survey organization. What is aimed at on the analytical side is the collection and examination of samples of typical profiles. The data for such profiles may be expected to give information as to the intrinsic character of the soil, apart from the accidental changes consequent on its recent agricultural history. Thus, whilst the texture of the soil, its moisture conditions, and its general behaviour under a given system of management may be inferred from the soil survey data, the actual plant nutrient status of individual fields will depend so much on their recent history that data can only be deduced from samples taken for the purpose. A record of such data is only of a temporary character.

In every advisory centre, large numbers of soil samples are dealt with annually in connection with requests for advice. The information obtained from the examination of these samples is doubly valuable because not only do they serve as a basis for practical recommendations, but they also serve to supplement the information obtained during the soil survey. And thus as time goes on and results accumulate, the adviser who is also conducting a soil survey gets to know what are the characteristics of each soil series from the standpoint of plant nutrient requirements. In the light of the information obtained in the soil survey the enormous mass of analytical data collected in normal advisory work acquires added significance.

The soil survey makes a valuable contribution to advisory work by extending the work of the provincial centre into places which might hitherto be unreached. We find that a large number of enquiries come as a direct result of the presence of soil surveyors in an area. Farmers who would otherwise scarcely overcome their natural diffidence are often quite willing to seek advice when they come into contact with surveyors mapping the soils of their area. In this respect experience varies with the district. During one season, for example, nearly sixty requests for advice were received

from one Welsh county. In other seasons, with the survey proceeding in other districts, considerably smaller numbers of requests have been received.

The soil survey renders a great service by increasing the adviser's knowledge of the soils of his area. However many cases may be dealt with arising out of the initiative of farmers seeking advice through their organizers, the adviser's acquaintance with his soils is incomplete and unsystematized until these soils have been mapped. The soil survey frequently corrects earlier impressions of an area and reveals unsuspected facts. I may give an instance from the results of this season's survey work of my colleagues, Messrs. D. O. Hughes and Evan Roberts in West Caernarvonshire. My general impression of this rather remote area was that it consisted mainly of rather light soils, particularly poor in lime. The mapping of recent months has revealed the wide occurrence of a series of soils of a heavy character having sub-acid surface soils, but lying over a highly calcareous boulder clay. The presence of this hitherto unsuspected soil series opens up a new view of the agricultural possibilities of the district in which it occurs.

The existence of a trustworthy soil map of the country will greatly facilitate the interchange of experience between one district and another. It may happen that a certain series is well known in one province, but only of limited extent in the second province. In such a case what appears at first a troublesome abnormality may be a soil series about whose treatment and agricultural possibilities a considerable amount is already known. Such correlations will only be possible when much more country has been surveyed. Indeed, the survey can only be expected to yield its full value when all the provinces have been mapped.

The Utilization of Soil Surveys.

In order to utilize the soil survey to the full much additional work is needed. This work falls under two main headings, namely, correlation with existing agricultural data, and experimental work.

With regard to correlation with existing agricultural data, it is true that soil surveyors do, in the course of their mapping, collect a considerable amount of information as to cropping, yields, etc. But I consider that a more efficient method would be to entrust this work to special investigators who would take the soil map as a base and work out their correlations. The same remarks apply to correlations with natural vegetation, pests, and the like. The soil surveyor has enough to occupy his attention in mapping soils, without being expected to take cognizance of everything that

depends on soil conditions. Ultimately the aim should be to build up a complete survey of all the factors affecting agriculture.

Both for the soil survey and for the general survey the historical aspect is important. Many of our survey problems might be solved if we knew more of the history of the soils which we are mapping.

Secondly, the utilization of the soil survey demands the institution of experimental work. I sometimes wonder that so much ingenuity has been displayed in devising statistical methods for increasing the significance of field experiments, whilst so little attention has been given to the question of their applicability to other conditions of the results obtained. It is certainly no mean achievement to carry through an experiment which demonstrates to the satisfaction of the statistician that treatment A gives a significantly higher yield than treatment B at Oak Farm, Ashton Parva, Loamshire; but can the statistician, can the adviser, or even the farmer, feel the same confidence that this knowledge, so painfully acquired, is valid for another farm, in another parish, in another county.

If, as I believe, there are differences in soils; and if, as I also believe, these differences can be reduced to an orderly classification capable of forming the basis of a system of mapping; if, in short, the soil series which we have recognized and mapped in the soil survey have any objective existence, these differences cannot be ignored in locating field experiments of any kind.

I would strongly urge that in all future field experimental work of whatsoever kind, the soil map, if it exists, should be taken as the basis in deciding locations. In the past, I am afraid that the location of field experiments has been too often decided rather by personal considerations, such as the keenness or willingness of a farmer or landowner, than by suitability of the soil. When the soil survey is sufficiently advanced for us to have an accurate idea of the principal soil series and their extent, it would be of great aid to advisory work if permanent experimental plots could be laid down on the more important soil series. This might mean half a dozen or more centres in each county, but I believe the results would have a significance and value far beyond the ordinary field experiment. Unfortunately, there does not appear to be money available at present for the institution of this type of experiment. There remains the less permanent type of experiment which is to some extent a demonstration. Here again, I would wish that where a soil map exists, it should be consulted before selecting centres.

I should feel that the survey had taken a great step forward if

it were possible to interest the county organizers and to convince them that the soil series mapped really exist and represent important agricultural facts. May I say, while on this point, that in the United States the soil survey is generally recognized, so that farmers and business men are as well acquainted with the significance of the names of soil series as they are with the names of breeds of stock or varieties of crop plants.

And so I say to the county organizer: come and help us make this soil survey more useful. With your intimate knowledge of the agriculture of your district you will appreciate the significance of the distinctions we have made in our maps. If, as I believe, you find it helpful to think of the soil problems with which you have to deal in terms of our soil survey classification, you will support us in our efforts to secure a fuller recognition for this work.

This fuller recognition must come if the soil survey is to be of value. At the present time, soil survey is leading a precarious existence in a few provincial areas. We are grateful that it has managed to survive, but we do feel that results cannot be expected unless the work is undertaken on a more extended scale. If it were possible to start a soil survey in each advisory province, it might be possible in a few years to get out a provisional soil map of the country as a whole. Such a map would be of great value in the planned development of agriculture to which we look forward. By increasing our stock of knowledge it would greatly increase the efficiency of the advisory service.

THE PRESENT CONDITION OF DRAINAGE AS A LIMITING FACTOR IN PRODUCTIVITY*

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That the year 1937 has been a most trying season for farming in England is reflected in all crop reports. Adverse weather and soil conditions during the first half of the year have dominated the situation, particularly in heavy land areas. These conditions came as a climax to several years of abnormal weather conditions, three drought years being followed by two which were excessively wet. Indeed, the summer of 1936 saw heavy land drains running vigorously in mid-July. There were no drying periods except in August, so that the land was in poor condition to face the following wet winter. A total of 4 inches of rain sufficed to saturate land which in 1934 had been able to absorb 11 inches without drains running.

In light open soils, abnormal and prolonged rises in the level of the water table have been general, with the result that flooded areas have been more widespread and extensive ponds have appeared and persisted in places where standing water has not been seen within living memory.

While it would be fatuous to pretend that all the adverse effects of this wet season might have been avoided by better field drainage, there is little doubt that the drainage properties and conditions of the soil have been decisive factors in the result. The areas to suffer were those where poor drainage conditions prevail. On this class of land field drainage has been neglected for two generations and its area steadily increases.

Drainage in England and Wales.

In considering the position with regard to drainage in England and Wales as a whole, and looking back over the past 100 years, there is no doubt that field drainage went ahead in a vigorous fashion during 1840–80. Following the Public Monies Drainage Act of 1847, some £9,000,000 was spent on land drainage, about half being advanced by the Government, and subsequently repaid. In 1880, before a Royal Commission on Agriculture, the drainage engineer, Bailey Denton, in his evidence, estimated that 3,000,000 acres had been under-drained during the preceding generation, but in spite of this he put the area of wet land still in need of attention at

* Paper read at Oxford, July, 1937.

15,000,000 acres, rather more than half the total agricultural area of the country. The former figure was based on information provided by tile manufacturers, the latter on the geological map of the country.

No field-to-field survey has ever been carried out, but there do exist pointers on the present-day position. Prior to the passing of the Land Drainage Act of 1930 it was stated (*Journ. Min. Agric.*, 1927) on official authority that there were 1,250,000 acres urgently needing drainage, due to liability to flooding by reason of defective arterial channels, and 500,000 acres capable of improvement by small drainage schemes, i.e. the cleansing of small streams and main ditches. These figures can, however, only refer to low-lying land, immediately affected by arterial drainage. The statement stressed the fact that it took no account of land capable of improvement merely by under-drainage. It is obvious that the area of such land must be substantial.

Some years ago the National Farmers' Union made an attempt to assess the position by circularising a simple questionnaire to its county branches, whose replies indicated that the total area of land capable of improvement by field drainage amounted to about 7,000,000 acres, or one-quarter of the whole. Some branches, as for instance in Beds., Herts., East Sussex, Leicester, Northants. and Worcester, put their estimates at 50–80 per cent. of the total; others in Hunts., Cambs., Essex, Bucks., Middlesex, Wilts., Isle of Wight and East Yorks. at 30–50 per cent. The biggest figures were associated with heavy soils and low-lying river valleys.

Data derived from a closer examination of the problem were recorded by R. McG. Carslaw in 1931. He dealt with some 170,000 acres, comprising 1,000 individual farms, spread roughly equally over heavy land, loams, and light soils in the eastern counties. His summary is as under:—

	Area in need of drainage.	Area drained in previous 5 years.
Heavy land	26 per cent.	8 per cent.
Loams	13 ,,	4·5 ,,
Light land	3 ,,	0·25 ,,
Whole area	14 ,,	5 ,,

The results of a field-to-field survey appear in a report of Hunter Smith and Williams in 1932 on the Barnet and District Grassland Competition. Primarily concerned with heavy London Clay soils, carrying much poor grassland, the report is nevertheless a telling commentary on the significance of field drainage. Without re-counting the findings in detail, it may be sufficient to say that the

judges found that 51 per cent. of 5,800 acres, in 32 holdings, suffered from defective drainage. In a similar fashion, the Herts. county authorities have arrived at figures of 5–12 per cent. on the light soils in the middle of the county and 16 per cent. on the boulder clay in the north.

GOVERNMENT ASSISTANCE FOR DRAINAGE.

One of the most significant and cheering features of the new national policy for agriculture is that at last attention is being directed to the soil itself and to the fundamental factors of fertility, as witness the amounts to be spent on lime, slag and drainage. The national contribution promised for the last-named is £140,000, described by Mr. Lloyd George as "preposterous" in the face of his estimate of 1,000,000 acres of land rotting and souring through lack of drainage. Though the contribution is small, it is to be welcomed as a recognition of the importance of drainage. The Minister rightly says that in drainage we must work from the sea up to the hill and only when the main rivers are got into good order can the government proceed up the hill and do something to help them. This view is presumably based partly on the danger of flooding in the lower reaches and the possible increased risks consequent on improved field drainage.

It is a specious argument that the better the land is drained the easier it is for surplus water to get away and therefore the greater the risk of flooding lower down. But the problem is not so easy as this. It certainly cannot be maintained that the big floods in various quarters in the last generation are due to the improvement of field drainage in the country as a whole. Some of the worst localised floods occur in towns and urban districts where the surface of the earth has been rendered absolutely impermeable by roofs, pavements and roads, and run-off as a result is instantaneous. On a former occasion evidence has been produced of the effect of increased permeability in soils in reducing the peak of field drain run-off and in spreading out the run-off over a longer period There are very strong grounds for the opinion that improved field drainage will lessen the risk of dangerous floods in main channels. In any case the importance of arterial channels should not be made an argument for inaction on the land behind them. Arterial drainage can give direct benefit only to a fraction of our ill-drained land.

To return to this £140,000. This, of course, is not all that is being done. As the Minister has pointed out, the Catchment Boards, since their inception in 1930, have accomplished a great deal, and some £6,000,000 has been spent on the main rivers. The

£140,000 is a recognition of the next step, to further the work of the small internal drainage boards, county councils, and rural district councils, struggling with the maintenance of subsidiary streams of less importance, but nevertheless public drains vital to agricultural land.

As an instance of this, one might quote the case of the Chesterton Rural District Council, which functions as a drainage authority around the town of Cambridge. Its area covers 112,000 acres with a rateable value of £108,000. Out of the rates the equivalent of 8d., or round about £3,000 per annum, is spent on drainage. Twenty men and a foreman are constantly employed in maintaining some 200 miles of minor streams and ditches. This burden on the locality is by no means a light one, yet it is admitted that much more ought to be done than is in actual fact. Although cases such as this are not of common occurrence it is obvious that there is still a mass of work to be done between the main drains of the Catchment Boards and the field drains of the farmer.

FIELD DRAINS.

And this is where, for the present, government assistance ends, although we are assured that those responsible are aware of what still lies untouched higher up the hill. There still remain to be considered the field ditches and the actual land drains. Both these concern the farmer immediately, and for most farmers they are of much more vital interest than arterial drainage works. Unfortunately, for over a generation now, there has been an increasing tendency from various causes to neglect them. Wherever agricultural opinion expresses itself on the drainage question, the cleansing of ditches is invariably stressed. There can be no doubt that the neglect of ditches has led more than anything else to the loss of much excellent tile drainage work of last century. To omit to carry out even the annual clearance of weeds will result in many outfalls being submerged the following winter when the drains begin to run. Further neglect causes accumulations of silt, the blocking of the drains and the waterlogging of the land they are meant to serve.

Even to-day, thorough cleaning of ditches would restore many such old drains to efficient service again, particularly in light land areas. The same is not necessarily true in heavy land, however, as will be seen. Instances are not uncommon in light land areas where the removal of anything up to three feet of silt and other accumulations have revealed extensive systems of tile drainage, in good order, which have functioned effectively as soon as their outfalls were uncovered.

The different conditions in heavy land may be illustrated by the case of an area of typical Gault Clay taken over by the Cambridge University Farm in 1930. The ground is all low-lying, but not flat, most fields having a moderate fall. It is all dependent on a small stream maintained by the local authority. The area was in a semi-derelect state and was immediately surveyed with a view to drainage. The ditches at that date were in poor condition, but the surveyor found 12 outfalls in a length of 900 yards, some running, some not. The whole area was then mole-drained, tile mains and new outfalls were provided, and the ditches were cleaned. The same ditches were cleaned again and deepened by 12–24 inches last spring. The operation revealed 35 separate outfalls.

This particular cleansing was carried out on a total of 1,232 yards of ditch, disclosing altogether 55 outfalls, of which only 3 belong to the present drainage system. They occurred at varying depths between 27 and 46 inches, but mostly at about 36 inches. The type and condition of the outfalls is indicated below:—

Diameter.	Total number.	Silted or otherwise choked.	Clear.
Less than 2 inches	20	18	2
2–3 ,,	15	11	3
3–4 ,,	5	3	2
4–5 ,,	13	0	13
5–7 ,,	2	0	2

The facts of this particular case have an important bearing on the whole question of drainage of heavy land. Over what period these many drains have been accumulating is uncertain, but they obviously represent many separate efforts to solve the problem. None of them have achieved more than a temporary mitigation of the evil due to the nature of the clay itself. Clays are impermeable and it is only the surface layer of soil which is endowed with any degree of permeability, which, alas, diminishes rapidly with depth.

One of the factors producing this permeability is seasonal weather changes and it is common experience that heavy land drains more freely after a droughty summer than after a moist one. So this natural permeability is primarily a seasonal variant. The different methods of field drainage first of all provide a graded system of channels by which the percolating water can escape, but they also produce a greatly enhanced permeability in the immediate vicinity of these channels due to the inevitable disturbance and opening of the soil which is caused, whether it be by the drainer's spade or by the passage of the mole plough. The value of the

original permeability will continue to wax and wane according to the season, but the artificially induced permeability above the channels will steadily decrease.

In drainage work, the tendency is to expect drains to last a long time. Something approaching permanency has been achieved, certainly, in the case of light land, but the heavier the land the less durable has any form of drains proved to be. The same attitude is frequently encountered with respect to mole draining. To some it is a matter of pride that their mole drains last 10, 15 or 20 years. The channels certainly may still be demonstrable, and the outfalls discharge, but the important point to consider is whether the drains are as effective as they were in the first half-dozen years of their life. If not, then the operation should be repeated as soon as circumstances allow.

Drainage of heavy land should be regarded as a cultivation rather than a permanent improvement. There are still heavy land farmers who are prepared to indulge in steam cultivations at 25s. to 30s. per acre, and within the last 6 years there has been no lack of experimenters in gyrotilling at 30s. per acre. In these days it is possible to mole drain and provide semi-permanent tiled mains with sound outfalls at 40s. per acre. Moreover, it is possible to re-draw the moles over the same mains at 14s. per acre. If the operation is only effective for 5 years—and it must frequently be effective for more—the cost of the operation surely is such as to justify its wider and more frequent employment.

The position in the country as a whole to-day seems to be that the neglect of ditch-cleaning has been responsible for the deterioration of field drainage conditions in light, medium, and heavy land alike. The heavier classes of land in addition, suffer from their own peculiar drawbacks. Periodical drainage operations have been abandoned, so that the innate impermeability of heavy land has become more and more a limiting factor. Any means of tackling these two problems should be explored. At the moment, in England, the State demurs at giving assistance in drainage beyond the spheres of local drainage authorities, but in Scotland, where arterial drainage is less necessary, the farmer or landowner does receive assistance in field drainage.

It is not so many years ago that a government scheme was operated successfully and effectively by certain county councils, for the restoration of many miles of the more important ditches. In 1929, for the mitigation of unemployment, the Ministry of Agriculture offered to contribute from 33–50 per cent. of the cost of tile drainage operations, to land owners willing to undertake such

schemes. By July, 1930, expenditure of £44,000 had been approved in 421 schemes throughout the country. As things stand, even ditching is an expense of serious dimensions, and remains essentially a task for manual labour. Annual cleaning costs about 2s. per chain, but the thorough removal of silt and falls every five or six years may cost as much as 7s. 6d. per chain.

The practice of surface draining might well receive more attention. The use of the common plough, as and when it is needed, is a cheap and efficient way of dealing with surface water.

In East Suffolk, on many soils, it is found to be the only satisfactory method. For the field drainage of most heavy land the mole plough remains the best available means. Present-day tractor performance has reduced the cost of moling to such an extent that it can and should be regarded as a routine operation, and there are good grounds for envisaging its possibilities as a means of renovating existing drainage systems over a wider range of soil conditions than those in which it excels of itself.

THE PRESENT POSITION OF GRASS DRYING*

By E. J. Roberts,
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Grass drying made its entry into farming practice in Britain in 1936, and, by the end of that season, was carried out at nearly 50 centres. The number of centres has now risen to approximately 75. This is considerably lower than was anticipated from the rapid increase in this development in its first year. Grass drying is subjected to more criticism than it was last year, but this is not unexpected, since, with a full year's results in the production and utilization of the product on the farm, it has become possible, for the first time, to weigh up both the advantages and disadvantages of the system under farming conditions.

The artificial drying of young grass in Britain owes its origin to the following assumptions, which research work was considered to have established beyond doubt:

(*a*) The nutritive value of young grass is high, the dry matter approximating to a protein concentrate.

(*b*) The nutritive value of young grass is independent of its botanical composition.

(*c*) The nutritive value of young grass is maintained into the autumn.

(*d*) Artificial drying enables the young grass to be preserved without loss of value or of palatability.

Has the experience gained from the first year of grass drying given any cause for doubting the validity of the above assumptions? These may be considered in turn.

(*a*) *The nutritive value of young grass is high.* This fact is still uncontested, and few critics would deny that, in the main, the dry matter of young, leafy grass approximates to some of the protein concentrates in feeding value. In practice, however, only about 25 per cent. of the grass that has been dried has been of this kind, the remainder having attained a more mature stage before it

* Paper read at Oxford, July, 1937.

was mowed. This is due to the very unequal rates of growth of pastures, and to the small outputs of the farm driers. Farmers and scientists alike are aware of the rapid growth of grass in the latter half of May, when the conditions as regards soil temperature, moisture, etc., become very favourable; this flush is generally followed by a period of less activity, about July, and later, by another but less intense flush, towards September. The producer of dried grass becomes acutely aware of the spring flush, when there is only a short interval between the times when the herbage is at the stage suitable for the drier, and in the super hay stage. To give an example of the rapidity of growth during the flush period, Stapledon and Davies found that, in one season, a number of grasses produced 76 per cent. of the season's growth from the middle of May to the middle of June.

Manuring has, hitherto, provided no solution to this problem; the peak in productivity is, if anything, accentuated by nitrogenous manuring. Some producers, for instance, planned to provide young grass only for their driers in 1936 by a programme of manuring at different times and of allowing some fields to remain unmanured. There was practically no growth on any of the pastures during April of that year, but, in May, rapid growth occurred on all, manured and unmanured alike. The solution of the problem of flush growth may, perhaps, be solved by the botanists, who may be able to offer a range of plants that reach the stage suitable for drying over an extended period. In the meantime, the problem must be tackled by cutting some of the grass for hay or silage, or by increasing output by field wilting.

The small outputs of the driers was one of the most disappointing features of 1936, and was largely responsible for the small proportion of young leafy grass that was used for drying in that year. The average rate of output for the season did not exceed 2 cwt. per hour, which was considerably lower than was anticipated. Thus, in practice, it has been found difficult to provide an adequate supply of young leafy pasturage for drying, a large proportion of the herbage having reached a stage too mature for drying when mown. This fact, however, while showing the difficulties on the production side, does not modify the position regarding the nutritive value of young grass.

Problems that are unsolved as regards the nutritive values and palatabilities of pastures, still persist when the herbage has been dried. Thus, if dried grass were produced from some of the famous fatting pastures in the Market Harborough district, it would be expected to give better results in feeding than dried grass produced

from other pastures, although there would probably be no difference shown in the proportions of crude protein, fibre, carotene, etc.

(*b*) *The nutritive value of young grass is independent of botanical composition.* No evidence has been obtained that gives any reason for modifying the conclusions from the Cambridge experiments, in which a botanically superior, and a botanically poor pasture gave similar results.

(*c*) *The nutritive value of young grass is independent of the season.* The work at Cambridge indicated that, by frequent mowing, the high nutritive value of pasture cuts could be maintained through the season, and into October; this was substantiated not only by analytical data, but by the digestibilities of the constituents. If this is so, the future of grass drying is assured despite other difficulties. Many graziers contend, however, that, whether kept short or not, grass produced in May and June is greatly superior for milk production and fattening to grass produced later in the season. Work at the Hannah Dairy Research Institute indicates that the proteins in autumn grass are of lower biological value than those of spring grass; it should be added, however, that the efficiency of the proteins in autumn grass was as high as those in bean meal, a food that has long been regarded as one of the best vegetable sources of protein for milk production.

(*d*) *Artificial drying enables preservation to be effected without loss.* There is no cause for any modification in the opinions on this point.

Thus, the situation regarding the fundamentals of grass drying remains practically unchanged, but the provision of a supply of young, leafy grass for drying has proved more difficult than was anticipated.

The Moisture Content of Fresh Grass.

The artificial drying of young grass is a formidable proposition, owing to its high moisture content. In wet weather, samples of grass may contain 85 per cent. of water; 80 per cent. is a common proportion in spring grass, even when no external moisture is present. When it is recalled that milk, with about 88 per cent. of water, does not contain much more moisture than this, the nature of the problem in grass drying can be realized.

In this regard, it may be stated that, in testing driers, the most important criteria are the amounts of water that can be evaporated per hour, and per unit weight of fuel. It is important that the various types of driers should not only be subjected to tests, but that these tests should be standardized. The high moisture content

of fresh grass often leads to difficulties in getting a uniformly dried product, damp pockets being apt to occur. Manufacturers are meeting this problem by the use of hand tedding, or by the use of a device for even spreading of the grass when it enters the drier, or by superposed conveyors, giving a cascading effect as the grass drops from one to the other.

Field wilting offers interesting possibilities of lowering drying costs, and of increasing throughput. By allowing the grass to remain in the field for some hours before taking it to the drier, the amount of water in it is lowered considerably. The disadvantages of partial field drying consist in the loss of colour, the increased costs of collection, and in the possibility of rain or dew negativing the benefits of the wilting; it is also possible that there may be some loss of dry matter even when wilting is carried out in dry weather. The merits of this system need careful investigation, and are the subject of experimental work at certain advisory centres and research stations; the possibilities of partial drying under cover, with the object of avoiding loss of colour, are also under test.

PROFITABLENESS.

The costs of producing dried grass in 1936 were higher than anticipated, having amounted to rather under £6 per ton; of this total, labour accounted for 33 per cent., coke for 20 per cent., depreciation for 14 per cent., and manures for 10 per cent. Costs for 1937 are being recorded by the Agricultural Economics Research Institute, Oxford, and by a number of advisory centres, so that it will be possible to find whether there has been improvement in this respect.

Where the produce was sold, it can be definitely stated that production in 1936 was profitable, though, possibly, the profits were slender in some instances. Prices ranged from about £6 10s. 0d. to £11 per ton. There are two markets for artificially dried grass and lucerne. There is a growing demand for a high grade product for incorporating in the foods of poultry and pigs kept on the indoor system since carotene is, at the moment, the only cheap source of a stable form of vitamin A. When required for this purpose, the dried grass commands a higher price than when wanted for ordinary farm use. The former demand is far from being satisfied at present, but, when there is a plentiful supply of a high grade product for this purpose, it is likely that the price of dried grass for ordinary farm use will be considerably lower than those that ruled in the winter of 1936–37. If high quality dried grass is valued according to the conventional method, i.e. on its starch and protein equivalent,

it is worth about £6 15s. od. per ton; this makes no allowance for carotene.

The profitableness of undertaking grass drying cannot be decided without taking account of the alternative means of utilizing grassland, and of its effects on the system of farming. Thus, if a farmer embarked on grass drying with the object of reducing his requirements of purchased concentrates, there would have to be a reduction in the head of stock, or some corresponding increase in the level of production. Some other aspects of the profitableness of artificial drying have also been discussed this season. It is strongly held by some that, owing to the great value to a farmer of having excellent hay every year, regardless of weather, there is a promising future for the use of artificial drying for completing the drying of hay that has been well wilted. For this purpose, baling could be dispensed with, thus reducing working costs by about 10s. od. per ton, and capital expenditure by about £140.

THE FUTURE OF GRASS DRYING.

There is no doubt that grass drying has come to stay. The results of the first year's operations may be disappointing, but in considering the future allowance must be made for the possibility of progress both by the engineer and the producer. The progress that this new development is likely to make depends, however, on

(*a*) Improvement in constructing driers of higher output, and at a lower price. An evaporation of less than 1,800 lb. of water per hour is not likely to interest the average farmer; this corresponds to the production of 4 cwt. per hour of dried grass (of 6 per cent. moisture content), from fresh herbage containing rather over 81 per cent. of moisture (4·3 water ratio). This output should be obtained with the minimum of damp pockets, and with but little loss of green colour. If a drier and baler of the above performance can be obtained for £400, excluding shedding but including drive for the fan, this new development will make rapid progress.

(*b*) More knowledge of the nutritive values of pasture cuts. If the short grass cut in late summer and autumn and containing a high proportion of crude protein has the high nutritive value indicated by laboratory experiments, the future of grass drying is assured, since it would not only reduce the amounts of purchased concentrates, but also open up a method for obtaining highly productive food from grassland throughout the season.

(*c*) Greater success in producing for the drier young, leafy pasturage, and not stemmy material. More experience in management, and help from the botanist in regard to the selection of crops with a wider range of cutting times offer possibilities in this respect. Experimental work now in progress will throw light on the value of field wilting as a means of coping with the growth of grass in flush periods, and thus enabling it to be dealt with before it has reached the stemmy condition.

THE ROOT EELWORM, *HETERODERA SCHACHTII*, SCHMIDT, IN RELATION TO AGRICULTURAL CROPS*

By W. E. H. Hodson,

The University, Reading

Some eighty years ago the Root Eelworm was first discovered on the roots of beet in Germany, and it was very soon realized that it was the underlying cause of beet sickness, a malady which threatened to wipe out entirely the sugar beet industry in that country. Later it was found upon oat, wheat and barley, and more recently upon pea, potato, tomato, and many other crops, and on weeds. At the present time it is known from some hundred different host plants, and ranks as an important pest nearly all over the globe. The principal agricultural crops attacked in Britain at present are sugar beet, mangold, potato, oat and other cereals, tomato, and quite recently turnip and kale.

Life History.

Attacks are confined entirely, or almost entirely, to the roots of plants, hence it is useless to look for the worms in stem or leaves. When immature the worms are minute and threadlike and only visible by aid of a microscope. They enter the roots from the adjacent soil, and feed usually in the vicinity of the root tips, and increase in size. The males remain more or less threadlike throughout their lives, but the females, unlike those of most eelworms, become globular in form when adult. When fully grown and fertilized they emerge from the roots, to the exterior of which they adhere; at first they are white in colour, later becoming lemon yellow and finally dark brown. In these stages they are easily visible to the unaided eye and are the eelworm cysts, which when present render diagnosis easy.

The cysts are the dried bodies of the females and contain enormous numbers of eggs. As the roots decay the cysts become mingled with the soil and constitute the source of infection for following crops.

Cysts may remain more or less dormant in the soil for several years, only gradually yielding up their contents of larvae. As soon as the favoured host plant is returned to the land, rapid hatching and emergence of remaining larvae take place and severe attack is

* Paper read at Oxford, July, 1937.

likely to occur. The explanation of this phenomenon lies in the fact that root secretions from the favoured host stimulate the larvae to emerge, and this is an aspect of the problem which is at present receiving considerable attention.

Despite the very formidable plant host list of the eelworm it, in common with many others, contains many biologic strains. That is to say a form of the eelworm attacking, say oat, is unable or unlikely to attack a sugar beet crop following on the same land. Often these strains are ill defined and it may be found that, as well as the crop host, weeds are also affected, thus materially complicating the problem of control by starvation.

SYMPTOMS OF ATTACK.

Sugar Beet and Mangold.—General unthrifty appearance, yellowing and wilting of outer leaves. Inner leaves small and dark green. Taproot small with excessive development of small rootlets giving whiskered appearance.

Turnip, Rape and Brassicae.—Growth poor, turnips often remaining little larger than well-grown radish. Excessive development of lateral roots as in beet.

Oat and other Cereals and Grasses.—Symptoms are visible often by time fourth leaf is formed. This leaf often becomes tipped with red or yellow, and eventually all leaves become yellowed; growth is excessively slow. The roots are very short and exceedingly branched, being quite unlike those of healthy plants.

Pea.—Growth poor and colour yellow, plants dying prematurely and blackened around collar. Root development very poor, and if the attack is severe root nodules scarce or absent.

Potato.—Extreme stunting of growth. Haulm bronzed or yellowed and drying prematurely, the lower leaves first curling upwards at the margins, then falling off, giving a spindly appearance. Root development very poor, much branched, while in extreme cases yield of ware tubers may drop to as little as 15 cwt. per acre.

The foregoing indicates that in the field the general above ground symptoms are highly suggestive of starvation and when observed in land thought to be in good heart they at once suggest that the eelworm may be present. Examination of the roots should provide a further clue; in particular thickening, shortening and excessive branching should be looked for. If cysts are present on the roots (as they may be as early as April in early potato districts, and as late as October on field turnips), diagnosis can be certain. If the eelworm is not at that stage of development its presence in

quantity may still be detected in quite a simple manner without dissecting the plants.

DETECTION OF CYSTS IN THE SOIL.

Usually it is found that attacks occur in well defined patches in the field, the patches extending year by year as the favoured host is again grown in the land.

Take a few ounces of soil in the immediate vicinity of apparently affected plants, avoiding as far as possible the inclusion of small pieces of stick, leaves, etc. Place the soil in a flask or bottle of white glass, an empty half-pint beer bottle for example. Fill the bottle to the brim with water (the addition of a little methylated spirits reduces the scum formed), shake the bottle vigorously a few times and then stand it upright for observation. If cysts are present in quantity they will almost at once commence to float upwards and will be clearly visible around the bottle neck.

This is a simple and most valuable method of diagnosis in the field even if no crop is on the land. It must, however, be realized that it gives no very accurate indication as to the actual eelworm population, for only microscopic examination can show what proportion of the cysts contain eggs.

Prevalence of the Eelworm.—Unquestionably upon all its host plants the eelworm is becoming more common in this country, and the predisposing cause is the frequent growing of any one crop too frequently upon the land.

The potato is the best illustration of this fact. Throughout the country allotments are becoming severely infested with the potato attacking strain, and in fact on many holdings it has now become quite impossible to grow a productive crop. Field plantings of potato are in some districts now affected, and it may be recalled that two years ago a farmer was sued by his landlord and lost the case. The decision was that he had farmed his land contrary to good practice in that he had grown potato too frequently, and thus had built up a large eelworm population to the serious detriment of the land.

The effect of this decision is more far reaching than is generally realized, because within the next few years mechanized cereal farms, and even sheep farms growing large areas of "keep", may find themselves in a similar predicament.

Sources of Infection and Spread.—Usually the spread in the field is slow. It is typical to find infected patches, ranging from a few square yards to several acres in extent. The patches undeniably

grow from year to year by migration of eelworms in the soil, and also by means of cultivations dragging the cysts for many yards or even from one field to another.

In the case of the potato it is tolerably certain that fresh centres of infection arise by way of cysts adhering to seed from diseased sources. Also, examinations of the washings from sugar beet factories have disclosed the presence of living cysts in the washings. The alternative method of increase, and a common one, is the building up of an indigenous weed-attacking population by the repeated growing of a cultivated crop on which the eelworm also thrives. Large populations once built up are likely to persist over many years, and thereby greatly reduce the value and productivity of the land.

Remedial and Control Measures.

The only certain remedy at present is a prolonged rotation on affected land and the avoidance of growing a susceptible crop twice consecutively at any time. Coupled with this there must be a strenuous campaign of weed eradication in order that the eelworms do not increase upon these.

For example with potato, if land is severely infested the crop should be kept off for no less than six years. Then one good crop can be anticipated, followed in every fourth year by a similar crop. Should potato be grown on the land twice consecutively the second growing will be at least a partial failure.

In general it may be said that the above applies to any susceptible crop or crops, but once diagnosis is certain it is usually advisable to enlist the assistance of the local advisory centre. The host range of the particular strain of eelworm present can then be determined, and with all the facts in view a suitable and convenient rotation may often be devised. For example, in one instance in which oat became impossible to grow, lucerne, which although a host plant was immune to the strain of eelworm concerned, was included in the rotation with complete success.

Again, trap cropping, temporary leys, etc., may in the particular circumstances afford a remedy.

For many years experimenters in numerous countries have been searching for a method of destroying the eelworms in the soil. So far nothing short of steam-sterilization, which is economically possible only on very limited areas, has proved really effective.

Instances in which substances such as chloride of lime, potash and cyanamide have enabled a crop to mature could be quoted almost indefinitely. Nevertheless every attempt to reproduce

these successes has only shown that a method successful under one set of circumstances may be quite ineffective elsewhere. Heavy dressings of farmyard manure will sometimes produce a good crop on heavily infested land. At the same time the nematodes flourish and multiply, and eventually the crops fail more miserably than before.

My own opinion is, after many years work on plant parasitic eelworms, that no direct attack by chemicals is ever likely to prove effective as a direct killer of the pest. But the very fact that the presence of a favoured host induces rapid emergence of the larvae points indubitably to chemical influence. It should not be impossible to determine the influences at work and perhaps administer a synthetic stimulant to the soil when the eelworms would emerge *en masse* and starve to death. Perhaps an easier method of achieving the same end would be by means of suitable trap crops sown and ploughed in before the eelworms have time to mature.

RECENT ACTIVITIES

THE 1937 SUMMER MEETING, OXFORD

It was something of an experiment for the summer meeting of the Association to follow immediately after an Agricultural Organizers' Conference held at the same place. Whether this would mean an attendance larger or smaller than usual was a question which added a spice of uncertainty to some of the preliminary arrangements. In the event, between 60 and 70 members were present, nearly all of whom, except the few ladies, were comfortably housed at St. John's College. The meetings were held at the School of Rural Economy and the adjoining School of Forestry, which, so to say, are in the back garden of the college; passing from the one to the others involved nothing more strenuous than a walk by Dr. Bidder's rockery.

Those members who were not already in Oxford assembled on Friday evening and fended for themselves, while the college hall was occupied with the official dinner of the Organizers' Conference. Business began the following morning, the whole day being given up to Committees.

Sunday afternoon saw two excursions. The more ambitious consisted of a tour along the Thames Valley and a visit to the National Institute for Research in Dairying at Shinfield, near Reading.

The party was received at the Institute by Professor H. D. Kay, who gave a brief account of the history of the Institute, the scope of its work and recent and prospective developments. It was gratifying to hear that in the latter is included the provision of additional laboratories to relieve the serious congestion in the existing laboratories.

A tour was then made of the four main departments of the Institute—dairy husbandry, including the farm, chemistry, bacteriology, and physiology and biochemistry, and of the dairy and the Stenhouse Williams Memorial Library. The party saw some of the developments which have taken place in the last three or four years, and discussed the work in progress with members of the staff. Among many items of interest were new methods, some of which have been devised at the Institute, for the control and improvement of the quality of milk and milk products, the recent

work on protein feeding standards in relation to milk production and the health of the dairy cow, experiments on cheese-ripening and on the bacteriology of the lactic acid organisms, an investigation into the occurence, and possible causes of, market milk with low compositional quality, enquiry into the cause and prevention of the "fishiness" in milk sometimes associated with the feeding of beet products, and the results of investigations on the dramatic effect of hormones on milk secretion. A grass-drying machine recently installed, and a self-recording mechanical milking outfit undergoing performance tests, were discussed with the Institute staff.

Then followed a visit to the Memorial Library, where developments in methods and organization were explained, and where tea was taken.

The second party stayed nearer home and visited the St. John's College Farm at Long Wittenham, under the leadership of Professor Scott Watson. The farm consists of about 450 acres of mostly unfenced land lying in the Thames valley, which at this point is broad and flat. Some of the land is fairly strong clay, and the rest is valley gravel also containing a good deal of clay. Practically the whole of it has always been under the plough. Six years ago the farm fell vacant, and the best offer for the new tenancy was from a farmer who said that if the college would grass down the farm and lay on water to the fields and fence them, he would consider paying a small rent. This offer was refused, and the management of the farm was handed over to the School of Rural Economy. The ploughland tradition has been maintained by the provision of a combine-harvester, a grain drier and three tractors, while a pig unit, and more recently a small market garden have been added. The regular labour strength is five men.

The farm thus constitutes a pioneer attempt at full mechanization on a comparatively small scale, an attempt which, in spite of difficulties, has met with a fair measure of success, as the farm has paid the rent in full and left a small profit after meeting interest and management charges. It is interesting that although it was the wheat quota that gave the incentive, it is the barley crop which has actually brought the better return.

There followed a demonstration of different types of track-laying tractor which had been brought over from the Field Station of the Institute for Research in Agricultural Engineering at Benson.

Before returning to Oxford the party repaired to the garden of "The Plough" for tea. It had been rumoured that the School of Rural Economy and the College had both kindly offered to be host on this occasion, and for a short time there were expectations of a

double tea. Perhaps it was; at any rate it was ample, and thanks are due to whichever body so thoughtfully arranged it.

The first of the two paper-reading sessions was held the next day, followed in the afternoon by the general meeting. A large gathering of members then took the opportunity of inspecting the Agricultural Economics Research Institute, where they had tea at the invitation of Mr. C. S. Orwin.

On the last day of the meeting the second paper-reading session was held, followed by an excursion to Lockinge to see some of the many undertakings which flourish on the estate of Mr. Lloyd, the Lord Lieutenant of Berkshire. The property consists of 18,000 acres, of which all but 4,000 are in chalk-down country. Ten thousand acres are in hand and are managed by Mr. E. Lousley, who proved to be a delightful host and guide, as well as a skilful and energetic farmer. The estate makes all its own bricks, tiles and drainpipes, cuts down and converts its own timber, has its own nurseries where young trees are propagated for future woodlands, makes its own wagons, carts and hurdles, digs its own sand and gravel, makes its own lime, does all estate repairs and shoes its own horses.

Two thousand head of cattle are carried, including 250 pedigree Dairy Shorthorns and 100 pedigree Guernseys, the rest being mainly Hereford- and Angus-Shorthorn crosses for beef production. There are upwards of 6,000 sheep according to the time of year, and 2,000 head of poultry. One hundred horses, all pedigree Shires, and 14 tractors go out to work every day.

It was impossible in the space of one short afternoon to do justice to such an "embarrass of riches," but the party saw enough to capture some of Mr. Lousley's enthusiasm, and to carry away impressive memories of sleek kine and busy workshops among the gentle foothills of the chalk. Looking back at the downs, the plantations could be seen laid out in the formation of the troops at the battle of Inkermann, to commemorate the occasion on which Lord Wantage, cousin of the present owner, won the Victoria Cross.

Nearer home the route lay through Bagley Wood. This formed part of the original endowment of St. John's for the purpose of keeping the college in firewood.

Thus ended a pleasant summer meeting. Had it been protracted only a little longer, members might have witnessed a peculiarly Oxonian phenomenon. It was on August 30th, 301 years ago, that Archbishop Laud, as Chancellor of the University, entertained King Charles I in the new library of St. John's. Thither year by year their ghosts return. Two unusual features distinguish these

apparitions. In the first place they carry their heads under their arms, which perhaps is not unreasonable, and in the second, they walk on their knees, the lower parts of their legs being out of sight. It is not generally known that some years ago the floor of that part of the library where they perambulate was raised about 18 inches, and the ghosts evidently prefer to walk on the floor which they used to know.

This veracious narrative is not without point. The college is just as glad to receive visitors to-day as it was in the seventeenth century, and it always looks for their return.

R. N. DIXEY

THE AGRICULTURAL EDUCATION EXHIBIT AT THE ROYAL SHOW, WOLVERHAMPTON, 1937

The task of writing a review of the Education Exhibit at the Royal Show has usually been undertaken by an outsider, who has not had any part in the preparation of the exhibit. Consequently there has been in the past rather a tendency for criticism to triumph over description. In the case of the Wolverhampton Show a pamphlet describing the exhibits was printed for general distribution on the ground, and in this article little will be written about the completed exhibit as it was during the show week, but some account of the genesis of the exhibit will be given and the private views of the writer.

A complete list of the individuals who took an active and effective part in the preparation of the exhibit is very formidable, and at one time it appeared that co-operation had run mad. But as affairs developed, things worked out very smoothly, and the sections dove-tailed together excellently.

The initial action of the R.A.S.E. in issuing an invitation in September, 1936, to the Heads of Agricultural Education in the area to meet one or two of the Society's officers for the purpose of selecting a site laid the foundation of the exhibit. Agricultural education in the neighbouring counties was committed to the enterprise and the Society had one item of their programme out of the way. The piece of land allotted for the exhibit was about half an acre of worn-out old turf land, and if anything was to be done in way of crop-growing it was necessary to push on with the preparation of the soil. A small committee, consisting of a representative from each of the four counties and the colleges in the area, drew up

a scheme of lay-out and this was adhered to all the time. Experience proved that there were one or two points on which the lay-out might have been improved, but it was not possible to foresee them as they did not really appear until the shedding was erected in June. The task of stripping and relaying the turf and working the soil was started early in October, and was chiefly done by one man, employed continuously till the Show was over.

When it came to the discussion of the details of the exhibits the West Midland Provincial Council, together with a representative from Worcestershire, became the responsible body, and from it no less than eight representative sub-committees were selected to deal with the following subjects:—Soils and crops, animal husbandry, dairying, horticulture, veterinary science, plant diseases, poultry husbandry and economics. All the schemes were drafted by the end of the year and every detail was established by the middle of February. The actual exhibit as shown to the public varied hardly at all from the forecasted arrangements.

The assistance of the art schools in Staffordshire was sought in the autumn. The idea of a series of decorated panels was taken up with enthusiasm and it was agreed to execute a frieze depicting the various branches of farming. Each of the ten art schools in Staffordshire agreed to do at least one panel. Apart from the intrinsic merit of the individual panels the whole effort was most noteworthy for the way in which the panels harmonized. After an initial meeting of the art masters at which sketches were submitted, the work of one school was never seen by any of the others.

The choice of subjects for display in the exhibit was the greatest difficulty that the Sub-Committees had to face. Workers in agricultural education are naturally forced to spend most of their energy on problems which may be local in character, but the Royal Show is national in its appeal. The committee were therefore restricted to matters which seemed to have the greatest appeal to the greatest number. As far as the outside part of the exhibit was concerned the question of having animals was ruled out. In spite of the universal appeal of anything in motion, be it a dog fight or a slowly-moving elephant, it was decided to limit the exhibit to matters of still-life. After all, crowd attraction did not seem to be so important as the attention of observant seekers after knowledge.

The idea of importing masses of soil on to the ground to drive home the impotance of soil acidity and so on was singularly happy, and it was so successful that now there is a feeling that this type of exhibit might have been used more extensively.

The relative proportions of space for the different exhibits were not easy to settle. As far as the promotors were concerned the team-spirit saved the situation. The balance of the exhibit as a whole might have been somewhat uneven. Yet during the progress of the show it was noticed that nothing was neglected by visitors, some wanting one thing and some another.

Early in the whole proceedings it became known that the design of the pavilion and the staging of the exhibits would be arranged by experts from the Ministry. Everything was to be done to plan and carried out according to canons of orderliness and good taste. An equally high standard had been set up, from the beginning, for the outside exhibit. It was largely this attention to detail that gave such a good general impression to the public at large. Comments on the exhibit both in the press and by individual observers were all favourable.

The exhibit had taken much time and energy and expense to produce and it was only a minute part of the show. Through pressure of other engagements on the ground many visitors never saw the exhibit at all, and those who did come mostly regretted that they could not spare the time to study all the different sections.

The Royal Show offers unique opportunities for a presentation of the results of agricultural education and research and my own opinion is that much is lost when an exhibit of this character is open to public view for only five days. The work and expense would hardly be increased at all if the education exhibit were open for several weeks, from the middle of June to the end of August.

This could be easily arranged if a site were selected to which entrance would be obtained only from within the yard during the show week, but at other times from outside. Before and after the show the exhibit could be opened at specified times on certain days of the week when members of the education staffs would be present to show visitors round. A small charge would be made to visitors except to those who were members of the R.A.S.E. With proper publicity, it seems that farmers and horticulturists within an hour's run of the show ground would make a point of visiting the exhibit several times to observe the progress of the experimental crops.

H. B. Tilley

THE FOURTH INTERNATIONAL GRASSLAND CONGRESS, ABERYSTWYTH, 1937

In 1928 the First Grassland Congress was held in Germany. Our grateful thanks are due to the early pioneers and to Germany. Naturally, like most beginnings it was small and unassuming, and was chiefly attended by neighbouring European countries. In 1931 the Second Congress was held in Sweden, and interest showed a healthy increase. In 1934, the Third Congress met in Switzerland, and although nominally still a Central European interest, Great Britain took part, while numbers and representation indicated that the work of the Congress was assuming international importance and recognition. In 1937, the Fourth Congress met in Great Britain and was definitely classified as international. This was clearly indicated by the fact that thirty-seven different countries of the world attended and the total number of delegates reached the high figure of nearly four hundred and fifty. This number included a large representation from the British Empire and U.S.A.

The Congress commenced at Oxford and after touring through many interesting grassland areas in England, passed into Wales. Aberystwyth, the headquarters for the Congress, was the centre for the paper-reading part of the Congress. The President was Professor R. G. Stapledon, C.B.E., M.A., a very capable and also a very charming personality, whose skilful guidance did much to make the Congress a success. Professor J. A. Scott Watson in the south, and Professor J. A. Hanley in the north, as Vice-Presidents, carried on with brilliant success the field side of the tour.

The organization of the Congress entailed the close co-operation and hearty goodwill of many people. This was generously given by all concerned. But the real work, which is not yet finished, in spite of going on continuously for over three years, has rested on the shoulders of the joint secretaries. We are all under a heavy debt of gratitude to Mr. William Davies and to Dr. R. O. Whyte for the splendid work done, often under great stress and considerable difficulty. They have the satisfaction that their long and arduous task has been a complete success.

The paper-reading part of the Congress was divided into General Meetings with plenary papers, and section meetings:—(1) Grassland ecology, (2) Seeds mixtures, etc., (3) Plant breeding, etc., (4) Fertilizers, (5) Nutrition: fodder conservation, and (6) Pastures,

management, yield, etc. The various papers were, like the Congress members, widely representative of vastly different conditions of grassland work throughout the various parts of the world. But, perhaps more important, were the opportunities readily taken advantage of, to meet and discuss personally the various problems and points of interest between various members of the Congress. It was this personal contact which made the Congress one large happy family instead of a large crowd. In spite of the large number the Fourth International Grassland Congress was a very great success.

No attempt is made to deal with any papers on the various sections as all the information can be obtained, either in the *Abstracts* (5s.) or in the final volume of papers to be published later. Similarly no mention is made of the truly lavish hospitality given by individuals and various bodies throughout Britain. It ably maintained the name and reputation of British hospitality at its best.

The first area visited naturally lay just outside Oxford. The chief interest was the very heavy soil, cracking badly in summer. Hence perennial rye grass does not grow to great advantage. In contrast to this the next type of grassland was much better, as the underlying soil was gravel though clay was plentiful on the surface. Next typical Downland (Chilterns) was examined and the results of different treatments shown. It was most interesting to see the deplorable condition of an area ploughed out during the war and since left with neither cultivation nor fertilization. It was an excellent example of the origin of quite a number of our present grasslands or pastures of both yesterday and to-day. It was evident that such land could be improved by suitable treatment.

Interesting also were the forestry plantations. It showed that there is considerable scope for further investigation of this use of different land, both in the downland and in other situations. It is not yet realized that trees (or woods) play an important part in the general economy of the land, and that forestry and agriculture are not necessarily antagonistic.

Cliveden House provided a sharp contrast in its grassland side to what was seen elsewhere. For a time the method of handling the pastures and the costly methods adopted were a puzzle to many of our friends from abroad. It took some time to explain that the pastures were for horses only (Cliveden Stud Paddock) and horses of a racing type in particular. For example, there must be a good carpet of grass which must be of high quality. A soft covering must be achieved to avoid hard ground during frost, or slipping, and at the same time provide grazing. Naturally, this is a costly

process. Ploughing must be frequent, particularly after a drought, providing high quality grazing and fresh ground for horses. Cattle under such a peculiar system are merely scavenging animals. Fertility is maintained in a high condition by very liberal manuring. A most interesting afternoon concluded by passing through the house and going through the fine gardens and seeing the wonderful panorama stretching for miles beyond the lawn and garden.

A visit was made to Rothamsted to see the old grassland plots. This part was almost in the nature of a pious pilgrimage. Apart from the fact that we travelled in motor buses, we were grassland pilgrims visiting one of the earliest centres of grassland research. Even the tales told in the buses rivalled those of Chaucer's fellow travellers to Canterbury. The plots at Rothamsted are (or certainly should be) sufficiently well known to require no repetition or description. One point only need be mentioned, that Dandelion (*Taraxacum officinale*) in one plot and Cow Parsnip or Hogweed (*Heracleum sphondylium*) in another, were very common weeds. This will be referred to later.

The Moulton Farm Institute was next visited. This Farm Institute enjoys a deservedly high reputation. Everything was "ship shape" and in order. The fields were in excellent condition and so was the stock. There was a certain amount of jocular criticism during the Congress, at the time and interest devoted to stock. It must be remembered, however, that grassland exists to provide food for stock, hence to neglect the stock side is impossible. Another point is that the type and the handling of stock are all important in the management of grassland. At Moulton Farm Institute, a building with raised tiers of seats and a small cattle ring with good entrance and exit for stock, made an excellent meeting for the Congress to see and hear from Mr. Stewart the points of various breeds. The quiet and expeditious handling of stock, without any excitement or flurry, was an object lesson on good sound training and discipline. Visitors thoroughly enjoyed their visit. It is a pity that more of our farm institutes do not follow the excellent example of Moulton and do the very valuable and necessary work of an institute, instead of trying to do the work of, and imitating, agricultural colleges. This unfortunate tendency has even spread to secondary and continuation schools, and is a purpose for which they were never intended. It is essential that the general educational side be attended to as well as the applied, or it ultimately affects the grassland outlook. There is ample room for all these educational units, but each should keep to its own particular sphere.

No tour would be complete without a visit to the Market Harborough district. Here are found the famous fattening pastures. To many, neither their appearance nor botanical composition seem very remarkable. This, to some extent, is due to the fact that they are often visited either at the dry part of summer, or immediately after (in early autumn). Naturally no pastures look their best either during or immediately after a spell of dry weather. The chief proof, however, is the result. Judging by the stock and their condition, there is nothing far wrong with the pastures, even during dry spells, and the regular succession of stock which leave the farms for market leave nothing to be desired. Every pasture is not necessarily a fattening pasture. Those which do not so rank are used for fattening heifers (more easily fattened) or for hay. The management of these fattening pastures consists in exercising extreme care in the stock, and, either resting during the winter or stocking very lightly with sheep. An interesting point is that young cattle do not fatten readily on these pastures. Poorer pastures were visited later, the chief difference was a higher proportion of Yorkshire fog and bent. Such pastures are used for fattening heifers.

The Cotswolds were next visited. Here was found much of interest. Formerly the area visited was largely arable, but now it is mostly grassland. The Hosier system—or a modification of it—is applied to both dairy farming and poultry. The land therefore receives a heavy dunging as well as dressings of basic slag. The result of this is a fine pasture, a high proportion of wild white clover, perennial rye grass, and an indigenous, or wild, form of red clover. Even the old downland is altered though Brome Grass (*Bromus erectus*) still persists, and where dunging has been heavy cocksfoot growth is dense and often suffers from rust (not determined) and Choke (*Epichloe typhina*). Here as at Rothamsted, dandelion and hogweed showed a marked tendency to increase with the use of dung. This recalls the many fields which are met with in Switzerland, whose vegetation consisted chiefly of these two species. These fields are cut frequently and are heavily manured with dung and/or liquid manure. This tendency should be watched, and on this account, the writer would urge careful and regular botanical analysis of the changes occurring in these Cotswold pastures under their recent treatment. Such records, with field notes, would not only be of great interest but of considerable value in the immediate future.

Next the seed growing and raising areas of Hereford, near the Welsh border, gave a very interesting insight into the methods

adopted by the Welsh Plant Breeding Station to get seed ripened in a drier area than Wales. The use of mustard seed with clover seed to show up the line of clover and facilitate weeding, is ingenious. Another method adopted to get good distribution and ease in sowing is to mix clover seed killed by heat with the seed to be sown. Questions of grazing and treatment are also considered and their influence on seed production. The application of manures is by no means similar for all grasses. With the addition of nitrogen timothy matures sooner, but the application of nitrogen (and the quantity) is important in the manuring of all grasses for seed production. The time of cutting back, the reduction of leafiness (temporary) as this is not favourable to seed production, are only two of the many problems that have to be faced.

From the Hereford area the "caravan" passed into Wales. Perhaps the most striking feature of Wales is the greenness of its hills due to the grassy vegetation. Both in the borders and in the Cahn Hill area this was a most noticeable feature. There were also wooded areas (natural, semi-natural and artificial) scattered along the valleys and at times at a considerable elevation.

It would be useless even to commence writing an account of the Cahn Hill Scheme. Full information can be obtained in various publications. The results are most striking, and it is amazing to see the proportion of wild white clover in swards situated at such a high elevation. In Wales, however, the problem of land improvement is not so difficult as in many parts of Scotland. There was considerable doubt regarding the soil acidity. Figures given varied from four to six for *p*H measurement. In any case, even if acid, there must be a good supply of available bases. Much of the unimproved land examined was more grassy and nutritious than some of the improved land in Scotland after very drastic treatment. In parts of Scotland the acidity is high, while in many cases the depth of soil, or workable soil is much less than that seen at Cahn Hill. Climatic differences must also be kept in mind. These remarks are not made with any disrespect to the great achievements at Cahn Hill, but to emphasize the truth that what succeeds in one place may not succeed in another. This point will be discussed later.

Some most interesting questions were raised regarding the Cahn Hill Improvement Scheme. Assuming that this method was adopted to any extent, would it pay? It would mean far more stock, and in consequence, could an economic market be found for the increase of stock caused by a spreading of the Cahn Hill Scheme? Again, forestry is said to compete with agriculture for ground which

is improvable. Is this competition necessary? It seems to the writer, that a working arrangement of forests and improved areas would be a mixed improvement, much more likely to withstand periods of depression, not to mention economic blizzards. Granted afforestation may need a large initial capital, but it also does put people back on the land, and home-grown timber is negligible in Britain. In many parts of Britain stock cannot be successfully out-wintered (or partially out-wintered) without the protection of a shelter belt. Planted-up or re-afforested areas could meet this need. Sound co-operation between agriculture and forestry would leave little ground unutilized and not only be of mutual benefit, but of great national benefit.

As with the Cahn Hill Improvement Scheme so with the Welsh Plant Breeding Station, it is impossible to do justice to the enormous volume of interesting work constantly in progress. The plant breeding side would fill volumes and has already done so—but that is not all the activities. The Biotica Plots with their different treatments were fascinating. They provide an explanation of the present vegetation of not a few British pastures. The effect of systems of management in swards was also another interesting series, the difference between night and day grazing, the difference between grazing and haying, and the time and period of rest. It was also evident that the pedigree strains were definitely superior to the ordinary commercial strain (under Welsh conditions). To mention only one other point in conclusion, that is the question of rushes. After cutting, hard grazing, and phosphate manuring, rushes must be searched for, so scarce are they. Will many other parts of Britain please note? For those who live in Britain there is no excuse for ignorance of the great work which is going on at Aberystwyth. If any are still in doubt, only one piece of advice can be given, go and see for yourselves.

From Wales the Congress passed to Newcastle to examine Northumbrian pastures. This provided a sharp contrast to Wales and the more Southern parts of England, approximating more nearly to Scottish conditions. A whole day was spent at Cockle Park, and it proved a day full of interest and enjoyment. Cockle Park might be aptly renamed Basic Slag. As with Rothamsted and Aberystwyth, so with Cockle Park, it is quite impossible to give an adequate description. Here again those who wish not merely to learn, but, also as important, to see—go and see for yourselves. There are the old academic plots now growing mellow, and many others besides.

The outstanding feature in this area is the splendid results

obtained with the use of basic slag. This was also evident even on high moorland. The arable crops as well as the grassland responded in a remarkable way. The unimproved areas of heather and some bracken, etc., lay side by side with the improved area with good pastures, fine crops of oats, and turnips. It was obvious that improvement was easier than in many parts of Scotland. Here again we suspect that it was in point of acidity or at least in available bases that at least some of these Northumbrian soils are better than many in Scotland. In this respect it is necessary to recall the fact that nearly half a century ago, the Cockle Park method was followed out at several carefully chosen Scottish centres and watched with equal care. With very few exceptions the results were disappointing, for the improvement was not nearly so marked as at Cockle Park. Once more we are faced with the well-known fact that what succeeds at one centre may be far from a success elsewhere. There is not merely soil difference, elevation, and exposure, but local or micro-climatic conditions.

Another feature much appreciated at Cockle Park was a demonstration of sheep dogs at work. Britain is famous for this, and Cockle Park ably maintained this tradition.

From Northumberland through a very heavy rain-storm Scotland was reached. Fortunately the sun broke through as the Congress arrived at Boghall Experimental Farm. Here were seen conditions totally different from those at Cahn Hill or even at Cockle Park. Acidity is the first of many problems, and spells of dry weather, or even drought, at the worst time of the year add still more to the difficulties of improvement. Phosphate, and even available nitrogen, are also frequent requirements. The constant selective grazing of sheep does not always help the best types of vegetation. Even ploughed-out and improved areas are frequently difficult and slow, and under such conditions the results at Cahn Hill and even Cockle Park are, in comparison, highly spectacular. Even so, steady progress has been maintained, and not the least successful advance has been the use of Galloway Cattle to keep down the rough herbage. That was why Lord Elgin in his address of welcome to Boghall Experimental Farm, warned the Congress that experiments were on a small scale. Such work must be accomplished and proved before any large-scale work is possible or safe. Under the difficulties of soil, topography, and local climate, Scotland must observe the old motto *festina lente*.

About one third of the Congress left Boghall and proceeded to the Scottish Plant Breeding Station at Craigs House, and the Scottish Plant Registration Station at East Craigs. There was

seen the work done for plant breeding in Scotland. Delegates from abroad were not slow to notice the small size, small staff, and obvious lack of finance in the Scottish Station compared with the Welsh Plant Breeding Station. In spite of this severe handicap, much interesting and valuable work was demonstrated, while the large number of potato plots illustrating different varieties and rogue types, proved of the greatest interest to many of the delegates.

Finally a tour of the Central Plain, the southern part of the Central Highlands, and the Trossachs, was made to give the delegates some idea of typical Scottish scenery and vegetation. It did give some idea of the vegetation of vast areas in Scotland. The obvious similarity of many parts to those in Central and North-Western Europe was mentioned by many delegates, who saw problems very similar to those with which they themselves were faced. On the homeward journey the timothy seed producing area on the fringe of Flanders Moss (Stirlingshire) was seen, and at the same time all that remains of a very great land improvement scheme carried out on a truly noble scale.

During the tour several grass-drying plants were inspected while at work. There are very sharp differences of opinion as to whether the cost of this process is economic. Some who adopted the idea have ceased to operate their plant as it proved too expensive. One large commercial undertaking was seen where the grass was first treated with boiling water. Many of us felt unconvinced that this was a satisfactory undertaking from a financial point of view. But, as none of us had any capital invested, or were asked to invest capital, we decided that "silence was golden." The method of baling hay in the field used at one farm was most interesting. This method has replaced grass drying. The hay is green, fresh, with a very pleasant aroma and seems to be mid-way between dried grass and a typical hay. To the writer there seem great possibilities in this method.

Several items on the tour brought out the very different outlook of various people. Several of our American friends wanted most of the trees cut down on the roadside as they obstructed the view. Also the trees in the hedges, and round fields, worried their economic minds. To the writer and many others, this would be to turn Britain, or a large part of it, into a bare and almost devastated land. Trees do give shelter—even as they cast shade, and do give pleasure in the countryside. Scattered through the countryside they do create that atmosphere of calm content, beauty, and restful peace, sadly lacking in most of the world to-day. Below them in drought

is found the only green and luscious grass, and their shade is merciful to man and beast.

Yet another item was the large areas of land not fully utilized, and where rural populations could be settled. This was particularly stressed by several very friendly delegates whose countries have done much in this respect, and whose Governments are not always reputed to see matters from quite the same angle as our Government. Be that as it may, these are points of supreme importance. As they pointed out, in time of stress a rural population is a national safeguard both in man power and food production. Such problems were not easy to elucidate till the extraordinary economic relations between Britain and the other nations of the commonwealth, as well as certain other nations whose business transactions are closely interwoven with ours are carefully explained. Our friends saw the difficulty of altering the *status quo*, but did think our present policy rather unsafe if ever a time of stress arose. They agreed that in much of her grassland Britain had enormous reserves if ever ploughing out was necessary, but that so much of the countryside was not being properly or fully utilized did both worry and disappoint them. How many Britons think of these things?

To-day our many friends who have returned to their respective countries and homes, carry in their minds and hearts a warm place for this small country of ours. They have seen that infinite variety of soil, vegetation, climate, agriculture, and even human type, which makes us what we are. In spite of many efforts by world reformers the heart of humanity remains much the same in most parts of the world. The fourth International Grassland Congress has done much to cement genuine friendships between fellow-workers in different parts of the world. Let us hope not merely in the interest of science, but, in the greater interest of humanity, that the leaven will do its peaceful but powerful work.

E. WYLLIE FENTON

OBITUARY

SYDNEY PENNINGTON

Emeritus Professor Sydney Pennington, who died at Newport, Salop, on 19th July, was born in 1869 and received his earlier education at Giggleswick School. After leaving school in 1888 he had four years' experience of practical agriculture in Shropshire. The next three years he spent in study at the Royal (Dick) Veterinary College, Edinburgh, and the Royal Veterinary College, London, obtaining the diploma of the M.R.C.V.S. in 1895. After this he again returned to farming till 1902, when he decided to enter upon another course of study. Consequently, at an age considerably beyond that at which men now commence their academic career, and with a very thorough knowledge of farming practice, he proceeded to the University of Edinburgh, whence he graduated with the degree of B.Sc. in Agriculture in 1905. His first teaching appointment was as lecturer in veterinary hygiene in the School of Agriculture at Ghizeh in Egypt. In 1908 he returned home, and was in that year appointed lecturer in agriculture at what was then University College, Reading. In recognition of his work he was elected the first Professor of Agriculture at Reading in 1920. After 25 years' service to the University of Reading, Pennington retired in 1933 and was accorded the title of Emeritus Professor.

Pennington will be remembered best as a great teacher by the many agricultural students who passed through his classes. He was himself so full of enthusiasm for his subject that he readily infected others and especially young minds. This was even more marked in his farm classes, where he drew so largely from his personal experiences. With Professor Pennington there was never any danger of the academic degenerating into the mere theoretic. In addition to his teaching duties, Professor Pennington had charge of the University Farm. When he commenced his work at Reading in 1908 he set himself the task of grading up a herd of Dairy Shorthorn cattle that would be eligible for registration in Coates' herd book, and at the same time of establishing a herd of cows on the University Farm free from tuberculosis and of good milking type. This he accomplished several years before his retirement and the herd remains as a record of achievement on the present University Farm. The herd of Dairy Shorthorns at the National Institute for

Research in Dairying was founded largely on cattle of Pennington's breeding.

Though neither an orator nor debater, Professor Pennington spoke with a sincerity of conviction and a directness of purpose that commanded attention. He loved what was best in literature and art, and gathered together a surprising amount of knowledge and information on many and varied subjects. He was absolutely devoid of pretentiousness or seeking after effect. Pennington carried into everyday life a dignity of thought and conduct that unconsciously raised the tone of those about him. Those of us who had the privilege and pleasure of knowing him will always remember a multiplicity of services and kindness.

JOHN S. L. WALDIE.

BULLETINS AND REPRINTS

Agricultural Education authorities are invited to send copies of their publications to the Editor for inclusion in this section.

ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE.

Guide to Cockle Park Agricultural Experiment Station, 1937 (Bulletin No. 50). By J. A. Hanley.

UNIVERSITY OF BRISTOL.

22, *Berkeley Square, Bristol.*

The Farm Economist. Vol. II, No. 6., April 1937.

UNIVERSITY OF EDINBURGH.

Edinburgh and East of Scotland College of Agriculture, 13, *George Square, Edinburgh.*

Guide to Boghall Experimental Farm, 1937.

Calendar for 1937–38.

DAUNTSEY'S SCHOOL.

West Lavington, Wiltshire.

Report on Experiments. 1935–37.

HARPER ADAMS AGRICULTURAL COLLEGE.

Newport, Shropshire.

The Feeding and Management of Pigs for Pork and Bacon. By Chas. Crowther. Price 1s. (by post 1s. 3d.).

This booklet, written by Dr. C. Crowther, gives a simple account of the essentials of the science and practice of pig management. It is written for farmers and contains few scientific terms other than those with which most farmers are familiar. Within its forty pages the booklet contains information on the housing, breeding, feeding, management, and common ailments of the pig. The food requirements of the pig at all stages are explained and illustrated by typical rations. A classification of all the common feeding-stuffs is given, and a simple system of compounding rations which enables full advantage to be taken of fluctuations in market prices.

SOUTH-EASTERN AGRICULTURAL COLLEGE, WYE, KENT.

The Journal, No. 40, July, 1937. Price 7s.

The contents include:—"The Control of Apple Scab: Allington Pippin and Newton Wonder, 1936," by W. Goodwin, N. H. Pizer, E. S. Salmon and W. M. Ware; "The Honey Fungus (*Armillaria mellea*) attacking Fruit Trees and Hops; with Observations on *Pholiota squarrosa* in Cherry Orchards," by E. S. Salmon and W. M. Ware; "The Downy Mildew of the Hop in 1936," by E. S. Salmon and W. M. Ware; "Early Promise — A New Variety of Hop," by E. S. Salmon; "Observations on the Preservative Value of Varieties

of Hops of the American Type," by E. S. Salmon; "Investigations on Machinery used in Spraying. Part IV. Nozzles," by Cornelius Davies and G. R. B. Smyth Homewood; "The Post-War Increase in Milk Production of England and Wales (1921–36)," by A. L. Jolly; "Conversion of a Pasture into a Cricket Ground and Lawn," by R. M. Harrison and I. V. Hunt; "Hop Tokens—Kent and Sussex," by the Rev. R. W. Acworth; "Brewers' Grains as a Substitute for Millers' Offals," by V. S. Fishwick; "Hop Drying," by A. H. Burgess; "'Meta-Fuel,' and Slug Control," by S. G. Jary and M. D. Austin; "Cooling of Milk in Sample Bottles," by H. Barkworth; "The Selection of Potato Seed," by N. L. Tinley; "Soil Profiles Developed on Limestone of the Upper Inferior Oolite, near Doulting, Somerset," by A. James Low; "Scheme for the Examination of Soil Detritals," by H. H. Glasscock; "Investigations on the Insect and Allied Pests of Cultivated Mushrooms," by M. D. Austin and R. S. Pitcher; "Notes on Diplopoda. IV. The Recognition of Some Millipedes of Economic Importance," by Sholto W. Rolfe; "The Artificial Drying of Pyrethrum Flowers," by S. G. Jary, J. T. Martin and F. Tattersfield; "Investigations on the Insect and Allied Pests of Cultivated Mushrooms. XI," by M. D. Austin; "Investigations on the Insect and Allied Pests of Cultivated Mushrooms IX," by S. G. Jary and J. H. Stapley; "A Note on *Tryoglyphus Longior* var. *Castellanii* (Hirst)," by S. G. Jary; "The Identity of *Tryoglyphus siro L.* (Gerv)," by S. G. Jary; "Tests of Insecticides against *Anthonomus rubi* (Herbst)," by S. G. Jary.

LINGNAN UNIVERSITY, CANTON, CHINA.

Lingnan Science Journal, Vol. XVI, No. 3.

MINISTRY OF AGRICULTURE.

"Manuring of Fruit Crops," (*Bulletin* No. 107), by T. Wallace. Price 1s. 3d.

"Cider Apple Production" (*Bulletin* No. 104), by T. P. Barker. Price 1s. 6d.

ISLE OF MAN BOARD OF AGRICULTURE.

The Manx Journal of Agriculture, Vol. IV, No. 2, July, 1937. Price 1s.

SHROPSHIRE COUNTY COUNCIL.

1, *College Hill, Shrewsbury.*

Shropshire Agricultural News, Vol. III, No. 4, April, 1937.

WORCESTERSHIRE COUNTY COUNCIL.

Department of Agricultural Education, County Buildings, Worcester.

Agricultural Chronicle, Vol. V, No. 4, August, 1937.

REPRINTS.

FENTON, E. WYLLIE: "Algae Studies from Boghall Glen (Midlothian)," II. *Scottish Naturalist*, July–August, 1937.

FENTON, E. WYLLIE : "Biological Notes for 1936," *Scottish Journal of Agric.*, Vol. XX, No. 1, Jan. 1937.

FENTON, E. WYLLIE: "Some Aspects of Man's Influence on the Vegetation of Scotland," *Scottish Geographical Magazine*," Vol. LIII, No. 1 (1937), pp. 16–24.

Greeves, T. N.: "The Control of Blight, *Phytophthora infestans* in Seed Potatoes by Tuber Disinfection." *Annals of Applied Biology*, Vol. XXIV, No. 1, pp. 26–32.

Ogg, W. G., and McLeod, Angus: "Reclamation and Cultivation of Peat Land in Lewis," IV. *Scottish Journal of Agric.*, Vol. XX, No. 2, April, 1937.

Saunderson, W. R., and Cairns, H.: "On the Control of Gooseberry Rust," *Annals of Applied Biology*, Vol. XXIV, No. 1, pp. 17–25. Feb. 1937.

Tervet, Ian W.: "An Experimental Study of Some Fungi Injurious to Seedling Flax," *Phytopathology*, April, 1937, Vol. XXVII, No. 4, pp. 531–46.

Waldegrave, The Earl, and Price, W. T.: "Grass Drying," *Bath and West Journal*, 1936–37.

Watson, J. A. S., Skilbeck, D., and Ellis, J. C. B.: "Experiments on the Relation of Energy-Intake to Live-Weight Increase in Fattening Sheep," *Empire Journal of Experimental Agriculture*, Vol. V, No. 18, April, 1937.

REVIEWS

Plant Ecology. By Hilda Drabble. Pp. 136 + 24 photographic illustrations. (Edward Arnold & Co.). Price 7s. 6d.

In this book "an attempt has been made to give, with a minimum of technical terms, a simple account of the relations between plants and their habitats as interpreted by present-day conceptions." It is divided into two parts. Part I deals with "the essential facts relating to soils and soil organisms; to the physiological processes carried on by plants; to modifications of plant-organs and to an introductory account of some of the ideas and terms associated with Ecology." This part of the book occupies 28 pages, so that the information given is necessarily very sketchy. There is no mention, in the chapter dealing with the soil, of the importance of reaction as measured by the hydrogen ion concentration, or other methods. Information on this point, together with a description of the simple soil determination apparatus now available, ought to be given in any book in ecology, however simple. Part II is divided into 18 short chapters each dealing with a plant community. These are very readable chapters, illustrated by numerous beautifully reproduced photographs due to Professor E. J. Salisbury. They should be extremely useful to the beginner in ecology, and also to others who are interested in the botany of their own surroundings, particularly since Tansley's *Types of British Vegetation* is no longer available. The agricultural botanist might not agree with several of the statements made in Chapter XVI on Grassland. Tall fescue and meadow fescue are usually rendered *Festuca elatior* and *F. pratensis*, and the white clover which occurs naturally in the so-called "neutral" grassland is not Dutch clover, but the wild white species. On many of these grasslands *Ranunculus bulbosus* is more plentiful than *R. acris* and *R. repens*. The description of water meadows would scarcely satisfy Mr. A. G. Street, whose "drowner" is such an interesting personality. On p. 59 and in the Index "Ransoms" should be Ramsons; on p. 103 we find *Spartina townsendii*, and in Plate X (*h*) *Spartina Townsendii*.

There is a short Bibliography. The book is well printed and strongly bound, and can be recommended to both teachers and students as an elementary handbook. D. H. R.

Grass Drying. By E. J. Roberts, M.A., M.Sc. Pp. 125 + 13 plates and a map. (H.M. Stationery Office.) Price 2s. net.

This is a Report prepared for the Committee on the Preservation of Grass and other Fodder Crops. There are chapters dealing with The Extent of the Grass Drying Movement; The Production of Suitable Herbage; The Water Content of Herbage; Cutting and Hauling; Furnaces, Fuels and Power; Grass-Drying Machines; The Cost of Producing Dried Grass. The booklet is illustrated with several diagrams and photographs, and a Bibliography includes 78 scientific papers. There is a good index.

Mr. Roberts's account deals with the general problems of grass drying, with special reference to the 1936 season; it is indispensable to those who wish to keep abreast of the developments in this promising agricultural development.

D. H. R.

Grass Drying. By S. W. Cheveley, M.Sc. Foreword by Sir Daniel Hall, K.C.B., LL.D., F.R.S. Pp. 127 and 9 illustrations. (London: Ivor Nicholson & Watson, Ltd. 1937.) Price 6s.

Mr. Cheveley has ably reviewed the whole situation of grass drying. In the first chapter the author gives an account of the present position, and a complete history of the progress commencing with the work of the late Professor T. B. Wood and Dr. Woodman in the year 1926 up to the end of 1936, when some 50 driers were in operation.

Chapter II deals with the case for crop drying, and elaborates the statement made in the foreword by Sir Daniel Hall that "Granted a sufficiency of dried young grass the British farm can become self-supporting for milk or meat production all the year round." The principles of grass drying are outlined in Chapter III, which includes a useful table showing the water ratio of different types of grass, and the statement is made that "economical drying depends mainly on two things—the thermal efficiency of the drier and the amount of labour required to work the plant." The next chapter summarizes the types of driers, that is the fixed tray drier, the band drier and those of the mobile type.

Costs of drying are given in Chapter V, and actual figures are quoted from six farms. The lowest complete cost of production of one ton of dried grass being £4 13s. 6d., and the highest £6 8s. 7d. Chapter VI is written on the installation of the drier, and mentions the sources of heat as coke, coal, anthracite and oil.

In dealing with the management of grass for drying, the author states that the production of grass for drying requires at least as much attention as haymaking or grazing, and then treats with fertilizing, rotation leys and other points of management. Chapter VIII on the cutting and collecting of grass also includes yields, short and long grass, the cut-lift method of harvesting and "wilting." The author gives a list of other farm crops suitable for drying with special reference to lucerne.

Chapter X deals with the value of dried grass, comparing the product to hay, oats and the concentrated foodstuffs, giving tables of the protein and starch equivalents, minerals and carotene values.

In the chapter "Feeding of dried grass," rations are given for all classes of live stock, but in dealing with pigs and poultry the author states somewhat high amounts. With pigs up to 15 per cent. of dried grass in the ration is recommended, but it has been found that pigs do not relish over 10 per cent. and probably 5 per cent. is the optimum amount. With poultry up to 25 per cent. of dried grass meal is recommended in the ration, but other opinions give 10 per cent. as the optimum amount.

The final chapter gives the author's views on future developments, and he quotes that the development of grass drying will depend upon the introduction of a cheap and simple drier, and the extension of credit to farmers for the purchase of such driers.

The author has presented throughout a fair picture of grass drying in this country. No undue claims are made, it is merely a statement of facts, and the book should prove a stimulation to further efforts on the part of agricultural engineers. Those who have studied the subject agree with the author that grass drying is a matter of simple economics, that is the cost of production compared to that of good hay.

There is no doubt that the book is a most valuable contribution on the subject of grass drying especially as the author has had a wide experience in this connection, and has been largely responsible for its commercial development, and the publication should prove a useful reference and a valuable addition to the bookshelf of the farmer, scientist and agricultural student.

W. T. P.

NOTES

The next meeting of the Association will take place in London during the Smithfield Show week, on 9th and 10th December.

Attention is directed to the advertisements which appear in this Journal. They are drawn up specially to assist those connected with agricultural education and research; when writing to firms for information, catalogues, etc., it will assist both advertisers and the Association if mention is made of AGRICULTURAL PROGRESS.

Although AGRICULTURAL PROGRESS consists chiefly of papers delivered at the yearly and half-yearly meetings of the Association, other articles of a suitable type may be submitted, and will be printed so far as space permits. Will all contributors please send in their copy typed on one side only of the paper, and correctly punctuated? Alterations in proof take up much time and are, therefore, expensive.
